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ANNUAL REPORTS

OF THE

WAR DEPARTMENT

FOR THE

FISCAL YEAR ENDED JUNE 30, 1900.

REPORT OF THE

CHIEF OF ENGINEERS.

PART 8.

WASHINGTON:
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1900.

CONTENTS.

[Alphabetical index will be found at the end of each part or volume.]

PART I.

OFFICERS OF THE CORPS OF ENGINEERS.

FORTIFICATIONS.

POST OF FORT TOTTEN, N. Y.—U. S. ENGINEER SCHOOL.—BATTALION OF ENGINEERS.—ENGINEER DEPOT.

OFFICER IN COMMAND, MAJ. JOHN G. D. KNIGHT, CORPS OF ENGINEERS—

RIVER AND HARBOR IMPROVEMENTS.

ATLANTIC COAST AND GULF OF MEXICO.

IN THE CHARGE OF MAJ. S. W. ROESSLER, CORPS OF ENGINEERS—

WESTERN RIVERS.

LAKE RIVERS AND HARBORS.

PACIFIC COAST.

MISCELLANEOUS.

SUPERVISION OF THE HARBOR OF NEW YORK.

BRIDGING NAVIGABLE WATERS OF THE UNITED STATES.

BRIDGES OBSTRUCTING NAVIGATION.

APPENDIX No. 4.

REPORT OF MAJ. JOHN G. D. KNIGHT, CORPS OF ENGINEERS.

PART I.

RIVERS AND HARBORS.

APPENDIX A.

REPORT OF MAJ. S. W. ROESSLER, CORPS OF ENGINEERS.

APPENDIX B.

REPORT OF MAJ. W. L. FISK, CORPS OF ENGINEERS.

APPENDIX C.

REPORT OF COL. CHAS. R. SUTER, CORPS OF ENGINEERS.

APPENDIX D.

REPORT OF MAJ. D. W. LOCKWOOD, CORPS OF ENGINEERS.

APPENDIX E.

REPORT OF MAJ. SMITH S. LEACH, CORPS OF ENGINEERS.

APPENDIX F.

REPORT OF MAJ. E. H. RUFFNER, CORPS OF ENGINEERS.

APPENDIX G.

REPORT OF MAJ. W. L. MARSHALL, CORPS OF ENGINEERS.

APPENDIX H.

REPORT OF COL. J. W. BARLOW, CORPS OF ENGINEERS.

APPENDIX I.

REPORT OF LIEUT. COL. C. W. RAYMOND, CORPS OF ENGINEERS.

APPENDIX J.

REPORT OF GEN. WM. F. SMITH, UNITED STATES AGENT, MAJOR OF ENGINEERS, UNITED STATES ARMY, RETIRED.

APPENDIX K.

REPORT OF LIEUT. COL. O. H. ERNST, CORPS OF ENGINEERS.

APPENDIX L.

REPORT OF LIEUT. COL. CHAS. J. ALLEN, CORPS OF ENGINEERS.

APPENDIX M.

REPORT OF MAJ. JAMES B. QUINN, CORPS OF ENGINEERS.

PART III.

APPENDIX N.

REPORT OF CAPT. E. W. VAN C. LUCAS, CORPS OF ENGINEERS.

APPENDIX O.

REPORT OF CAPT. J. C. SANDFORD, CORPS OF ENGINEERS.

APPENDIX P.

REPORT OF CAPT. CASSIUS E. GILLETTE, CORPS OF ENGINEERS.

APPENDIX Q.

REPORT OF CAPT. C. H. McKINSTRY, CORPS OF ENGINEERS.

APPENDIX R.

REPORT OF CAPT. THOS. H. REES, CORPS OF ENGINEERS.

APPENDIX S.

REPORT OF CAPT. C. A. F. FLAGLER, CORPS OF ENGINEERS.

APPENDIX T.

REPORT OF MAJ. WM. T. ROSSELL, CORPS OF ENGINEERS.

APPENDIX U.

REPORT OF MAJ. H. M. ADAMS, CORPS OF ENGINEERS.

APPENDIX V.

REPORT OF MAJ. H. M. ADAMS, CORPS OF ENGINEERS.

PART IV.

APPENDIX W.

REPORT OF CAPT. C. S. RICHÉ, CORPS OF ENGINEERS.

APPENDIX X.

REPORT OF MAJ. THOS. L. CASEY, CORPS OF ENGINEERS.

APPENDIX Y.

REPORT OF CAPT. ROBERT McGREGOR, CORPS OF ENGINEERS.

APPENDIX Z.

REPORT OF CAPT. EDW. BURR, CORPS OF ENGINEERS.

APPENDIX A A.

REPORT OF MAJ. C. McD. TOWNSEND, CORPS OF ENGINEERS.

APPENDIX B B.

REPORT OF MAJ. F. V. ABBOT, CORPS OF ENGINEERS.

APPENDIX C C.

REPORTS OF LIEUT. COL. AMOS STICKNEY, CORPS OF ENGINEERS, PRESIDENT MISSOURI RIVER COMMISSION.

APPENDIX D D.

REPORT OF CAPT. H. M. CHITTENDEN, CORPS OF ENGINEERS.

APPENDIX E E.

REPORT OF LIEUT. COL. M. B. ADAMS, CORPS OF ENGINEERS.

PART V.

APPENDIX F F.

REPORT OF MAJ. DAN C. KINGMAN, CORPS OF ENGINEERS.

APPENDIX G G.

REPORT OF MAJ. W. H. BIXBY, CORPS OF ENGINEERS.

APPENDIX H H.

REPORT OF MAJ. CHAS. F. POWELL, CORPS OF ENGINEERS.

APPENDIX I I.

REPORT OF CAPT. H. F. HODGES, CORPS OF ENGINEERS.

APPENDIX J J.

REPORT OF CAPT. GEO. A. ZINN, CORPS OF ENGINEERS.

APPENDIX K K.

REPORT OF MAJ. CLINTON B. SEARS, CORPS OF ENGINEERS.

APPENDIX L L.

REPORT OF CAPT. J. G. WARREN, CORPS OF ENGINEERS.

APPENDIX M M.

REPORT OF MAJ. J. H. WILLARD, CORPS OF ENGINEERS.

APPENDIX N N.

REPORT OF CAPT. CHESTER HARDING, CORPS OF ENGINEERS.

PART VI

APPENDIX O O.

REPORT OF LIEUT. COL. G. J. LYDECKER, CORPS OF ENGINEERS.

APPENDIX P P.

REPORT OF COL. JARED A. SMITH, CORPS OF ENGINEERS.

APPENDIX Q Q.

REPORT OF MAJ. T. W. SYMONS, CORPS OF ENGINEERS.

APPENDIX R R.

REPORT OF CAPT. GRAHAM D. FITCH, CORPS OF ENGINEERS.

APPENDIX S S.

REPORT OF CAPT. JAMES J. MEYLER, CORPS OF ENGINEERS.

APPENDIX T T.

REPORT OF LIEUT. COL. WM. H. HEUER, CORPS OF ENGINEERS.

APPENDIX U U.

REPORT OF CAPT. WM. W. HARTS, CORPS OF ENGINEERS.

APPENDIX V V.

REPORT OF CAPT. W. C. LANGFITT, CORPS OF ENGINEERS.

APPENDIX W W.

REPORT OF CAPT. HARRY TAYLOR, CORPS OF ENGINEERS.

APPENDIX X X.

REPORT OF LIEUT. COMMANDER JOHN C. FREMONT, U. S. N., SUPERVISOR.

PART VII.

APPENDIX Y Y.

REPORT OF THE MISSISSIPPI RIVER COMMISSION.

G. L. GILLESPIE, colonel, Corps of Engineers, U. S. A., president; Amos Stickney lieutenant-colonel, Corps of Engineers, U. S. A.; Thos. H. Handbury, major, Corps of Engineers, U. S. A.; Henry L. Marindin, assistant, United States Coast and Geodetic Survey; B. M. Harrod, Robert S. Taylor, and J. A. Ockerson, commissioners.

APPENDIX Z Z.

REPORT OF THE MISSOURI RIVER COMMISSION.

PART VIII.

APPENDIX A A A.

REPORT OF THE CALIFORNIA DÉBRIS COMMISSION.

APPENDIX B B B.

APPENDIX C C C.

APPENDIX D D D.

APPENDIX E E E.

APPENDIX F F F.

REPORT OF LIEUT. COL. CHAS. J. ALLEN, CORPS OF ENGINEERS.

APPENDIX G G G.

REPORT OF LIEUT. COL. A. M. MILLER, CORPS OF ENGINEERS.

APPENDIX H H H.

REPORT OF COL. THEO. A. BINGHAM, U. S. ARMY.

APPENDIX I I I.

SURVEY OF NORTHERN AND NORTHWESTERN LAKES.

APPENDIX J J J.

REPORT OF CAPT. H. M. CHITTENDEN, CORPS OF ENGINEERS.

APPENDIX K K K.

RECONNOISSANCES, EXPLORATIONS, AND WORK IN THE FIELD, IN MILITARY DIVISIONS AND DEPARTMENTS.

APPENDIX L L L.

REPORT OF CAPT. H. M. CHITTENDEN, CORPS OF ENGINEERS.

APPENDIX M M M.

REPORT OF CAPT. H. M. CHITTENDEN, CORPS OF ENGINEERS.

APPENDIXES

TO THE

REPORT OF THE CHIEF OF ENGINEERS,

UNITED STATES ARMY.

(CONTINUED.)

APPENDIX A A A.

ANNUAL REPORT OF THE CALIFORNIA DÉBRIS COMMISSION FOR THE FISCAL YEAR ENDING JUNE 30, 1900.

CALIFORNIA DÉBRIS COMMISSION,
San Francisco, Cal., July 2, 1900.

GENERAL: The California Débris Commission has the honor to submit the following annual report for the fiscal year ending June 30, 1900. Previous reports of the Commission may be found as follows:

1894, Report of Chief of Engineers, U. S. A., pp. 3169 to 3177.
1895, Report of Chief of Engineers, U. S. A., pp. 4049 to 4075.
1896, Report of Chief of Engineers, U. S. A., pp. 3861 to 3874.
1897, Report of Chief of Engineers, U. S. A., pp. 3961 to 3980.
1898, Report of Chief of Engineers, U. S. A., pp. 3549 to 3569.
1899, Report of Chief of Engineers, U. S. A., pp. 3747 to 3768.

The Commission was created by act of Congress approved March 1, 1893. During the past year its members have been the following officers of the Corps of Engineers, viz: Col. S. M. Mansfield, Lieut. Col. W. H. Heuer, and Capt. Herbert Deakyne. Colonel Mansfield has been president of the Commission and Captain Deakyne has been secretary.

The jurisdiction of the Commission extends to hydraulic mining in that portion of the State of California drained by the Sacramento and San Joaquin River systems.

The duties of the Commission may be briefly stated to be: First, the prevention of such hydraulic mining as may be deemed injurious to the navigable waters within the Commission's jurisdiction, permitting, under proper regulation, such mining in cases where it can be carried on without such injury; second, to mature general plans for the improvement of the rivers whose navigability has been injured by hydraulic mining, and, if practicable, to devise general methods whereby such mining may be carried on without damage to the navigable waters.

The State Débris Commissioner, the Hon. John F. Kidder, has been present at most of the sessions of the Commission held during the year.

Mr. Hubert Vischer, civil engineer, has been in the employ of the Commission throughout the year, inspecting the operations of mines working under permits from the Commission, looking after illegal mining in the district under the Commission's jurisdiction, conducting investigations of sites for restraining works in the Yuba River, and making plans and estimates for the works. His duties have been very arduous and have been performed with commendable skill and energy.

PREVENTION OF ILLEGAL MINING.

In accordance with the opinion of the Attorney-General of the United States (Appendix A, House Ex. Doc. No. 11, Fifty-third Congress, third session), the Commission has, since the date of its last

annual report (July 1, 1899), called the attention of the owners and operators of three mines, which were being worked illegally, to the requirements of the law and the duties of the Commission in the matter. So far as known, these mines, which are all small, were closed in compliance with the orders of the Commission, and in two cases applications were subsequently made for permission to mine.

On June 8, 1897, the Commission received notice from the United States district attorney that the injunction suit requested by the Commission on December 4, 1894, against the North Bloomfield Mining Company, had been decided by Judge Ross, of the United States circuit court, in favor of the United States, and that the injunction had been issued. On June 22, 1897, the Commission was informed that an appeal had been taken by the North Bloomfield Mining Company and that their motion to vacate the injunction pending the appeal had been granted. No further official information concerning the case has been received.

APPLICATIONS AND PERMITS.

The Commission has, since it organized, received 474 applications to mine; 367 permits have been granted. A table showing a synopsis of the applications received and the action taken is appended and marked A.

Thirty-seven permits have been at different times temporarily suspended, generally on account of the neglect of the owners to comply with instructions concerning the impounding works or on account of accidents to those works.

One hundred and forty-five permits have been revoked since the organization of the Commission, in most cases because the mines have been worked out or abandoned, or have changed hands.

The Commission has been informed by the proprietors of three mines working under permits from the Commission that their operations have been stopped during the year by injunctions issued by the court of Sutter County, Cal. When the first case of this kind arose, the Commission requested instructions as to its duty in the premises and the Attorney-General of the United States, in a letter addressed to the Secretary of War, August 9, 1899, decided that as there appeared to be no question raised as to the validity of the permit issued by the Commission, it was not expedient for the Commission or any department of the Government to intervene in the suit.

Accordingly, the Commission has taken no action in these cases.

The requirements in respect to storage of detritus exacted by the Commission during the past year have been the same as those during the previous year.

No considerable failure of impounding barriers has come to the notice of the Commission during the year.

The total amount of material mined under permits during the year is estimated at 1,500,000 cubic yards.

IMPROVEMENT OF RIVERS.

The duty of devising plans for the improvement of the rivers concerned devolves upon the Commission by section 4 of the act. A board has since been appointed, in accordance with the act of Congress approved June 3, 1896, and charged with the duty of preparing plans

for the improvement of Sacramento and Feather rivers. The act creating this board being of later date than the act creating the Commission, the duty of improving these rivers has been taken up by the board. No plans for the improvement of the San Joaquin River have been made by the Commission, for the reasons that this stream is but slightly affected by mining débris and its improvement is under the charge of the engineer officer in whose district it is situated.

The report of the Commission on its investigation of sites for restraining works in the Yuba River, together with plans and estimates for the works recommended by the Commission, was submitted January 30, 1900, and is printed as House Doc. No. 431, Fifty-sixth Congress, first session. These plans provide for the construction of various works in the Yuba River at an estimated total cost of $800,000. For their construction there is now available $500,000, of which one-half was appropriated by the United States and one-half by the State of California. The fact that the amount available is not equal to the estimated cost of the works has caused some uncertainty as to the possibility of beginning work until further appropriations are made, but it is believed that the following provisions of the act of Congress approved June 6, 1900, will enable work to proceed without delay:

Land for débris dams and impounding works in California: From the funds appropriated by the river and harbor act of eighteen hundred and ninety-six for the construction of débris dams and impounding works in California, the sum of ten thousand dollars may be expended for the purchase of lands necessary for the construction of said works: *Provided*, That an equal amount is paid by the State of California: *And provided further*, That the Secretary of War may proceed at once with the construction of said works and that the gross expenditure for lands in the construction of said works shall not exceed in the aggregate twenty thousand dollars: *And provided further*, That where in such works more than one dam or impounding work is embraced within a project the Secretary of War may proceed to construct the said works in parts or sections and submit the plans and specifications for such parts or sections to the State board of examiners of said State for approval under the laws thereof: *And provided further*, That in all cases one-half of the expense of such works shall be paid by the State of California.

Money statement.

July 1, 1899, amount appropriated by act of March 3, 1899, for "Expenses of California Débris Commission, 1900"	$15,000.00
Amount expended during the fiscal year ending June 30, 1900	12,591.61
Amount unexpended on June 30, 1900	2,408.39
Outstanding liabilities	277.75
Balance (reverted to Treasury)	2,130.64
July 2, 1900, amount appropriated by act of June 6, 1900, for "Expenses of California Débris Commission, 1901"	15,000.00
Amount estimated to be necessary for expenses of California Débris Commission for the fiscal year ending June 30, 1902	15,000.00

Respectfully submitted.

S. M. Mansfield,
Colonel, Corps of Engineers.
W. H. Heuer,
Lieut. Col., Corps of Engineers.
Herbert Deakyne,
Captain, Corps of Engineers.

Brig. Gen. John M. Wilson,
Chief of Engineers, U. S. A.

APPENDIX A.

Synopsis of applications for authority to mine, with action taken thereon.

No.	Name of mine.	County.	Name of applicant.	Mine drains into tributary of—	Nature of tailings reservoir proposed for present use.	Approximate amount of gravel proposed to mine.	Application received.	Order issued to build impounding works.	License granted.	Mined and stored previous to May 1, 1900.
						Cu. yds.	1893.			*Cu. yds.*
1	Kelly Hill *a*	Butte	R. M. Mooer	Sacramento	Rock dam 30 feet high in dry ravine; side spillway cut in rock.	1,000,000	Aug. 2	Sept. 9, 1893	Mar. 27, 1894	9,000
2	Farrel *b*	Nevada	Eureka Lake and Yuba Canal Co.	Middle Yuba.	Dam 12 feet high of earth and logs across mouth of old hydraulic pit.	212,000	Aug. 11	Works already built.	Sept. 8, 1893	177,972
3	Omega *c*	do	N. C. Tully	South Yuba	Dam 60 feet high in Scotchman Creek of brush and gravel; side spillway cut in rock.	2,160,000	Aug. 16	Sept, 9, 1893	Nov. 11, 1895	....
4	Brandy City	Sierra	A. Steinberger	Middle Yuba.	Brush and earth dam across mouth of old hydraulic pit.	1,520,000	Sept. 19	Oct. 25, 1893	Oct. 9, 1894	99,800
5	Blue Nose *d*	Plumas	B. Below	Middle Feather.	Stone dam in Hopkins Creek.	50,000	do	....	....	....
6	Blue Gravel *b*	Yuba	Excelsior Water and Mining Co.	Yuba	Old hydraulic pit with tunnel stopped with rock.	604,000	Sept. 27	Works already built.	Oct. 17, 1893	529,614
7	Illinois Gold Gravel *e*.	Plumas	H. Buckley and Louis L. Hillman.	do	do	35,000	Sept. 29	Jan. 4, 1894	Jan. 31, 1894	7,951
8	New York Gold Gravel	Sierra	Westall & Hughes	South Yuba	Brush, log, and earth dam in Howard Creek. Spillway in rock.	484,000	Oct. 12	Nov. 21, 1893	Dec. 5, 1893	65,500
9	Corbiere & Bean	Butte	Corbiere & Bean	North Yuba	Rock dam 10 feet high in Hampshire Creek.	12,000	Oct. 9	Works already built.	Nov. 21, 1893	11,740
10	Phœnix Gold Gravel	Sierra	W. A. & M. E. Schofield.	do	Dams in Whisky Creek and North Fork of Slate Creek.	1,660,000	Oct. 14	June 27, 1894	....	....
11	Eureka Mining Co	do	Eureka Mining Co	do	Timber dams in Sawmill Ravine.	553,000	Oct. 15	Nov. 21, 1893	May 29, 1894	66,120
12	Craycroft Mining Co	do	Craycroft Mining Co	do	Timber dams in Hughes and Davidson ravines.	140,000	do	do	do	54,000
13	Excelsior Hydraulic	do	Excelsior Mining Co	do	Timber dams in Eagle Gulch and Smith Flat.	277,000	do	do	do	31,000
14	Spanish Ranch	Plumas	Quincy Mining and Water Co.	North Feather	Timber dams in Spanish Creek and old hydraulic pit.	8,000,000	Oct. 18	....	....	....
15	Gopher Hill	do	do	do	do	2,000,000	do	Dec. 6, 1893	Apr. 14, 1894	384,701

16	Polar Star f	Placer	John Spaulding	Bear	Stone and gravel dam in Little Bear River, with spillway.	605,000	Nov. 3	Works already built.	Dec. 13, 1893	12,800
17	Agate	Sierra	A. Denmire	North Yuba	Dams in dry ravine	17,000	Nov. 6	Dec. 13, 1893	Nov. 20, 1894	4,025
18	Nevada g	do	Geo. W. Cox	Yuba	Dams in North Branch of Slate Creek.	10,000	Nov. 14	June 27, 1894		
19	Fifty-four Flat h	Amador	Fifty-four Flat Mining Co.	Mokelumne	Brush dam in a ravine	15,000,000	do	Jan. 11, 1894	Feb. 6, 1894	34,446
20	Red Hill	Shasta	Nathan Gardiner	Sacramento	5 dams in gulch	750,000	Nov. 16	Jan. 4, 1894	do	17,730
21	Badger	do	W. R. Stewart	do	Flat ground	2,500	Nov. 29	No works required.	Jan. 2, 1894	35
22	First Chance i	Sierra	Frank E. Barbero	North Yuba	Bowlder, log, and brush dam in Howard Creek.	200,000	Dec. 4	Works already built.	do	834
23	Tannery Ravine i	Yuba	W. R. Reed	Yuba	Log and brush dam in ravine.	9,000	do	Jan. 4, 1894	Jan. 10, 1894	70
24	Mateos i	Sierra	Manuel Mateos	North Yuba	Westall & Hughes' dam in Howard Creek.		do	Works already built.	Jan. 2, 1894	
25	Davis j	do	Jos. Davis	do	do		do	do	do	12,173
26	Christmas Hill k	Placer	Hannah McKinstry, E. E. McKinstry, and E. E. Gilbert.	American		200,000	Dec. 5			
27	Walker l	Shasta	Olonzo Engle and F. Walker.	Sacramento	1 rock and 1 brush dam in Pomroy Gulch.	675,000	Dec. 8	Jan. 4, 1894	Jan. 31, 1894	1,076
28	North Star m	Calaveras	Phil McGuire, P. McGuire, jr., and B. McGuire.	Mokelumne	Dams in Buckeye Gulch	500,000	Dec. 13	do	Jan. 10, 1894	31,618
29	Hustler n	Nevada	Jos. Hustler	South Yuba	Gravel dam in Gilroy Cut	90,000	Dec. 17	Jan. 31, 1894	Aug. 13, 1894	19,850
30	Green Mountain h	Calaveras	J. W. Smith	Calaveras	Old hydraulic pit with brush dam.	250,000	do	Jan. 4, 1894	Jan. 8, 1894	3,534
31	Noonday i	Sierra	John Egbert	North Yuba	Flat near mine	40,000	Dec. 26	No works required.	Oct. 23, 1894	8,775
32	Pomroy l	Shasta	John McGrew and Olonzo Engle.	Sacramento	Rock dam in Pomroy Gulch.	1,400,000	do	Works already built.	Jan. 31, 1894	6,737
33	Union o	Yuba	C. C. Beever	Yuba	Rock and brush dam in French Gulch.	3,200	do	Mar. 7, 1894	Mar. 27, 1894	605
34	Welch Placer l	Sacramento	Columbian Gold Mining Co.	Cosumnes	Stone dam	161,000	Dec. 27	Jan. 31, 1894	Feb. 10, 1894	428,000
35	French Corral p	Nevadn	Kate Hayes Mining Co.	South Yuba	Old hydraulic pit	450,000	do	do	Mar. 13, 1894	
36	Manzanita q	do	do	Yuba	do	1,159,500	do	Apr. 10, 1894	May 1, 1894	833,200
37	Campo r	Yuba	Fausteno Campo	do	Rock dam in gulch	1,000	Dec. 29	Works already built.	Mar. 7, 1894	
38	Herring Ravine b	do	J. M. Wetmore	do	Rock and brush dam 1 mile below mine.	660	1894. Jan. 10	do	do	390

a License revoked February 25, 1895.
b Mine worked out. License revoked May 28, 1900.
c License revoked April 12, 1897.
d Permit refused.
e Mine now operated by Sam Ahtye.
f See supplemental application No. 193.
g Mine will not be worked.
h License revoked June 25, 1900.
i Mine worked out. License revoked May 7, 1900.
j Now operated by Hansen Brothers.
k Will not be worked.
l Mine worked out. License revoked April 23, 1900.
m Mine worked out. License revoked May 21, 1900.
n License revoked May 9, 1898.
o See supplemental application No. 267.
p Mine abandoned. License revoked May 28, 1900.
q License revoked January 19, 1897.
r Mine abandoned. License revoked May 21, 1900.

APPENDIX A.—*Synopsis of applications for authority to mine, with action taken thereon*—Continued.

No.	Name of mine.	County.	Name of applicant.	Mine drains into tributary of—	Nature of tailings reservoir proposed for present use.	Approximate amount of gravel proposed to mine.	Application received.	Order issued to build impounding works.	License granted.	Mined and stored previous to May 1, 1900.
						Cu. yds.	1894.			*Cu. yds.*
39	Conduit Ravine *a*	Yuba	W. W. & W. A. Lemon	Yuba	Rock and brush dam	10,000	Jan. 21	Mar. 7, 1894	....	....
40	Motor *b*	do	Jas. Gordon	do	Old water reservoir	10,000	do	No works required.	Mar. 7, 1894	200
41	Spring Gulch *c*	Calaveras	J. S. White	Calaveras	Old reservoir and dams in Spring Gulch.	545,000	Jan. 31	Works already partly built.	Mar. 13, 1894	27,100
42	Crane Brothers *d*	Yuba	Crane Brothers	Yuba	No impounding works necessary.	1,000	Feb. 5	No works required.	Mar. 7, 1894	973
43	Indian Hill *e*	Plumas	F. Eyraud and Jean Lassier.	Feather	Dam across natural depression.	118,000	Feb. 6	....	....	....
44	Badger Hill *f*	do	E. B. Jacks	do	Quincy Mining and Water Co.'s dam in Spanish Creek.	100,000	Feb. 7	....	....	....
45	Snow Brothers	Eldorado	Snow Brothers	American	Timber and brush barrier in Webber Creek.	903,000	Feb. 13	Works already built.	Apr. 3, 1894	82,750
46	Green Meadow	Calaveras	H. B. Havens	Mokelumne	Brush dams in gulch	93,000	Feb. 15	Mar. 14, 1894	Apr. 17, 1894	27,345
47	Grub Flat *g*	Plumas	John Tucker and S. C. Brown.	Feather	Brush and log dam in old pit.	20,000	do	Apr. 10, 1894	Apr. 14, 1894	13,615
48	Oriental and Tahoe	Nevada	Jas. Hackett	Yuba	Brush dam in swale and brush barrier on sloping plain.	56,000	do	Apr. 3, 1894	Aug. 6, 1894	1,340
49	Eureka Hydraulic *d*	Eldorado	Pascoe & Gruben	American	Brush dam in Chili Ravine	24,200	Feb. 19	do	Apr. 10, 1894	20,100
50	Spanish Hill Hydraulic. *b*	do	El Dorado Water and Deep Gravel Mining Co.	do	2 brush dams in Spanish Ravine.	129,000	do	Mar. 28, 1894	do	5,250
51	Spanish Hill gravel *h*	do	Thos. Alderson	do	Brush dam on flat	193,000	do	do	do	....
52	Cleveland *i*	Sierra	D. Perkins	North Yuba	Log dam in Rock Creek	125,000	Feb. 24	June 27, 1894	Nov. 27, 1894	20,100
53	Dutra, Wilder & Co.	Yuba	Lewis Wilder	Yuba	Rock dam across ravine	120,000	Mar. 5	Oct. 23, 1894	Feb. 5, 1895	1,200
54	Mitchell Hydraulic	Eldorado	Robert, James, and John Blair.	American	Brush and gravel dam in ravine.	1,161,000	Mar. 7	Oct. 9, 1894	Oct. 23, 1894	11,813
55	Stewart Hydraulic *j*	do	John Melton	do	Brush dam in ravine.	7,250	Apr. 3	Works already built.	May 1, 1894	....
56	Nip and Tuck *d*	Butte	Dickhouse Bros	Feather	Dam on flat in Robinson Ravine.	12,700	Apr. 19	Sept. 25, 1894	Oct. 2, 1894	1,000
57	Concordia *k*	Plumas	L. V. Tefft	do	Dams in Cogswell Ravine and Jackson Creek.	1,450,000	May 16	July 3, 1894	....	....
58	Northern Placer *j*	do	Northern Placer Mining Co.	do	Dams in Little Long Valley Creek.	100,000	do	June 27, 1894	Nov. 6, 1894	24,460
59	Schuyler *l*	Shasta	Thos. White	Sacramento	1 rock and 2 brush dams in Dry Creek.	296,800	June 5	Works already built.	July 23, 1894	11,450

60	Hayes and Steelman	Sierra	Philip Hayes	Feather	Log and brush barriers in excavations.	150,000	June 12	Oct. 23, 1894		
61	Mohawk *m*	Plumas	Stephen Soracco	do	Log and brush dam in ravine.	16,000	July 17	Aug. 14, 1894	Mar. 30, 1896	466
62	William Tell	do	Frank F. Vanzini	do	Log and brush dam in Yankee Ravine.	24,000	do	do		
63	Garfield Flat	do	Peter Lorenzo	do	2 brush dams in Squirrel Creek.	30,000	do	do	Nov. 6, 1894	2,879
64	Grizzly Bear *n*	do	Nicola Rossi	do	do	80,000	do	do	do	5,037
65	Howard	Shasta	Jas. Regan and J. M. Lowe.	Sacramento	2 brush dams in ravine	4,500	July 18	Oct. 22, 1894		
66	China Hill	Amador	Consolidated Amador Volcano Hydraulic Gold Mining and Land Co. of California.	Mokelumne	Log and brush dam in south branch of Sutter Creek.	968,000	July 25	Aug. 14, 1894	Nov. 13, 1894	8,664
67	Elephant	do	do	do	Log and rock dam in Dry Gulch.	330,000	do	do		
68	Steel & Co	Yuba	T. H. Steel	Yuba	Stone dam on New York Flat.	145,000	do	Works already built.	Sept. 25, 1894	92,700
69	James Watson	Shasta	J. C. Voluntine	Sacramento	Brush dams in Dry Creek and Jackass Gulch.	1,000,000	July 30	Oct. 9, 1894	Mar. 12, 1895	471,460
70	Volcano Gold Gravel *o*	Amador	Volcano Gold Gravel Mining Co.	Mokelumne	Log and brush dam in Sutter Creek.	32,000	Aug. 16	Sept. 18, 1894	Nov. 13, 1894	15,000
71	Holloway *o*	Plumas	J. S. Gould and F. M. Spencer.	Feather	Log and brush dam in canyon.	30,000	Sept. 5	Works already built.	Nov. 20, 1894	38,194
72	Mugginsville	Sierra	W. A. Morse	North Yuba	Crib dam in Eureka Creek	450,000	Sept. 7	Oct. 30, 1894	Nov. 11, 1895	36,500
73	Waukshaw	Nevada	John R. Jones	South Yuba	Rock dam in canyon	150,000	Sept. 10			
74	U. S. Grant *p*	do	E. P. Hagar and Samuel Peck.	do	3 brush dams in canyon	25,000	Oct. 23	Nov. 27, 1894	Dec. 17, 1894	3,300
75	Richmond Hill *l*	Plumas	Good Hope Mining Co.	Feather	Log crib dam in Onion Valley Creek.	72,000	Oct. 24	do	Nov. 18, 1895	98,066
76	Pine Grove *q*	Amador	Ben Hur Mining Co	Mokelumne	Brush dam, Sawmill Gulch.	25,000	Nov. 3	do	Jan. 8, 1895	4,000
77	Hidden Treasure *s*	do	Chas. G. Haskin	do	Log and rock dam in Grass Valley Creek.	30,000	do	do	Mar. 30, 1896	23,066
78	Martelle *t*	Eldorado	Leonard Dormody	American	Martelle Creek	30,000	Nov. 3	Jan. 22, 1895	Feb. 18, 1895	200
79	Gold Run	Placer	Gold Run Ditch and Mining Co.	do	2 rock dams in North Fork of American River.	11,655,000	do			
80	Spanish John	Nevada	John Black	Yuba	Log and brush dams in blind ravines.	121,000	Nov. 8	Nov. 27, 1894	Dec. 17, 1894	25,140
81	North Rim *u*	Placer	G. H. Pease and J. B. Golwell.	American	Dam in Mexican Gulch	10,000	Nov. 20	Feb. 12, 1895	Feb. 26, 1895	4,000
82	Crown Point *d*	Plumas	Crown Point Mining Co.	Feather	Log and brush dam in Porter Ravine.	45,000	Nov. 26		Apr. 15, 1895	2,850

a Mine abandoned.
b Mine worked out. License revoked April 23, 1900.
c License revoked June 18, 1900.
d Mine worked out. License revoked May 28, 1900.
e License refused June 27, 1894.
f License refused April 9, 1894.
g Now operated by H. A. Hallsted.
h Mine abandoned. License revoked May 21, 1900.
i Now operated by Joel Bean. License suspended April 2, 1900.
j Mine abandoned. License revoked May 28, 1900.
k License refused Feb. 23, 1897.
l Mine worked out. License revoked Apr. 23, 1900.
m License revoked June 25, 1900.
n License revoked Aug. 23, 1897.
o License revoked June 25, 1900.
p License revoked May 6, 1895.
q License revoked Apr. 22, 1895.
s Mine worked out. License revoked June 11, 1900.
t Mine worked out. License revoked June 4, 1900.
u Mine worked out. License revoked May 21, 1900.

APPENDIX A.—*Synopsis of applications for authority to mine, with action taken thereon*—Continued.

No.	Name of mine.	County.	Name of applicant.	Mine drains into tributary of—	Nature of tailings reservoir proposed for present use.	Approximate amount of gravel proposed to mine.	Application received.	Order issued to build impounding works.	License granted.	Mined and stored previous to May 1, 1900.
						Cu. yds.	1894.			*Cu. yds.*
83	Spring Valley *a*	Butte	Mariano C. Mello and John Costa.	Feather	Rock dam in Sawmill Gulch.	484,000	Dec. 3	Feb. 26, 1894	July 20, 1896	18,750
84	Kentucky Flat *b*	Eldorado	H. E. Picket	American	Log and brush dam in North Otter Creek.	100,000	Dec. 5	Works already built.	Feb. 5, 1895	22,758
85	Johnson *c*	Amador	Wm. Johnson	Sacramento	Brush dam in ravine	100,000	Dec. 10	Jan. 15, 1895		
86	Henrietta *d*	Eldorado	El Dorado Water and DeepGravel Mining Co.	American	do	7,000	Dec. 11	Works already built.	Jan. 22, 1895	750
87	Leroy Hedge *e*	Yuba	Leroy Hedge	Yuba	Brush, log, and rock dam below mine.	2,500	Dec. 14	do	Feb. 5, 1895	500
88	Epley *b*	Eldorado	Louis Rolland and Alonzo Vanderberg.	American	Brush, gravel, and rock dam in ravine.	3,500	Dec. 18	do	Jan. 22, 1895	200
89	York Mining Co	Yuba	York Mining Co	Yuba	Brush and log dam	4,000	Dec. 20	do	Feb. 5, 1895	12,520
90	Last Chance *e*	Eldorado	Edward Hancock and W. H. Daly.	American	Brush and gravel dams in Hancock Ravine.	50,000	Dec. 21	do	Jan. 22, 1895	8,060
91	Goodman & Bund	Amador	Goodman & Bund	Mokelumne	Timber and brush dam in Ashland branch of Sutter Creek.	100,000	Dec. 24	do	Jan. 14, 1895	5,250
92	Goodman Bros	do	F. A. and W. H. Goodman.	do	do	50,000	do	do	do	1,586
93	'49 Flat *f*	do	Hadley & Bolles	do	Log and brush dam in '49 Gulch.	250,000	Dec. 26	do	do	24,900
94	Fine Gold *g*	Calaveras	G. A. Meincke, C. Sanguinette, and J. S. Shepard.	Stanislaus	Rock and brush dam in Skunk Ravine.	4,000	Dec. 27	Feb. 26, 1895	Mar. 5, 1895	84,250
							1895.			
95	American House *b*	Plumas	A. Blair	Feather	Dams, American House Ravine.	2,500	Jan. 7	do	May 13, 1895	207
96	Central Hill Placer *f*	Calaveras	Wm. Thomas, sr., M. McCormick, W. A. Bisbee, and W. Thomas, jr.	Stanislaus	Rock and stone dams	1,000,000	do	Works already built.	Mar. 25, 1895	14,380
97	Kate Gray	Amador	Giovanni Rossi	Mokelumne	Brush dam	10,000	do	Feb. 26, 1895	Mar. 5, 1895	600
98	Spring Tunnel and Spring Canyon.	Eldorado	Jay E. Russell	American	Brush dams in Spring Canyon.	56,000	Jan. 17	Apr. 23, 1895		
99	Shealor *h*	Amador	J. E. Newsom	Mokelumne	Log, rock, and brush dam in Sutter Creek.	1,500	Jan. 29	Works already built.	Mar. 5, 1895	250
100	Railroad Hill Gravel.	Calaveras	Gianni and Luigi Demartini.	Calaveras	Brush dam in Dry Gulch	48,000	Feb. 1	do	Feb. 26, 1895	19,220
101	James Slater	Yuba	Jas. Slater	Yuba	York Mining Co's dam	30,000	Feb. 4	do	do	

102	Grizzly Hill[i]	Amador	Moy Jin Mun	Mokelumne	Brush dam in ravine	300,000	Feb. 12	Mar. 19, 1895	Apr. 8, 1895	180
103	Deer Valley	Eldorado	Wulff Bros	American	Log and brush dams and old pit.	5,000	Feb. 13	Works already built.	Mar. 18, 1895	
104	Strawberry Placer[j]	Calaveras	John Enos	Stanislaus	2 rock dams in Dry Gulch	3,000	...do	...do	...do	1,855
105	Mount Gregory Gold	Eldorado	Porter Philips	American	Brush and log dam in dry ravine.	200,000	Feb. 20	...do	Apr. 22, 1895	2,330
106	Red Hill and Telegraph Hill.	Amador	Geo. R. Evans, John Erickson, and M. Fitzgerald.	Mokelumne	Log crib dam in Chili Gulch.	15,000	Feb. 23	...do	Mar. 18, 1895	7,810
107	Blacklock[e]	Eldorado	Geo. W. Edwards	American	Brush and gravel dam in Spanish Ravine.	403,000	Mar. 1	...do	Apr. 1, 1895	4,740
108	Kelly & Matherly[k]	Placer	M. A. Kelly and W. H. Matherly.	...do	Worked-out pit	20,000	Mar. 5			
109	Dry Gulch[f]	Amador	O. M. Henry		Brush dam	10,000	Mar. 7	Works already built.	Apr. 8, 1895	500
110	Sawmill Flat	Shasta	J. K. Williams	Sacramento	Worked-out pits	30,000	Mar. 8	Mar. 13, 1895		
111	Mooney Placer[e]	Eldorado	Thos. Ewing	American	Log and brush dams inclosing worked-out pit.	968,000	Mar. 13	Works already built.	Apr. 1, 1895	3,000
112	Grizzly Flat[l]	...do	Geo. Wheeler and Moses C. Wheeler.	Cosumnes	Log and brush dam on Grizzly Flat.	10,000	Mar. 16	Apr. 1, 1895	...do	
113	Gold Deposit	...do	David Croft	American	Retaining wall, old hydraulic pit.	18,000	Mar. 22	Works already built.	Apr. 22, 1895	2,378
114	Railroad Placer	...do	Wm. F. Coe	...do	Brush dam	3,000	Mar. 23	Apr. 23, 1895	Sept. 30, 1895	649
115	Independence	Yuba	John A. Broyles	Yuba	Letsome Ravine	1,800	Mar. 27		Mar. 17, 1896	1,235
116	J. C. Day[m]	Eldorado	J. C. Day	American	Brush dam in ravine	1,000	...do	Apr. 23, 1895	Mar. 30, 1896	418
117	Iowa	Placer	William, Henry, and John Henning.	...do	...do	1,150	Mar. 29	Apr. 22, 1895	May 13, 1895	1,450
118	Tiger	...do	Jas. Ward and Wm. McDonald.	...do	...do	7,000	Apr. 1	...do	...do	1,475
119	Hard Times[n]	...do	Jos. J. and A. A. Hoffmann and H. McDonald.	...do	Brush barriers and old hydraulic pit.	30,000	...do	Works already built.	Apr. 22, 1895	1,650
120	El Dorado Placer	Eldorado	Wm. and Wm. J. S. Bacchi.	...do	Brush dam in small stream.	4,000	Apr. 3	...do	...do	1,209
121	Zantgraf & Closs[o]	...do	J. Zantgraf and J. J. Closs.		Worked-out pit	4,200	Apr. 9	...do	Apr. 29, 1895	
122	St. Lawrence[p]	Nevada	Ah Wing	Yuba	Brush dam in Illinois Canyon.	150,000	Apr. 15	July 2, 1895	Oct. 28, 1895	3,900
123	Polar Star[q]	Placer	John Spaulding	Bear	Liberty Hill dam in Bear River.	2,000,000	Apr. 17			
124	Liberty Hill[q]	Nevada	T. G. Phelps	...do	...do	144,000	Apr. 25			
125	Lost Camp[l]	Placer	J. B. Rathburn et al	American	Log and brush dam in Woods Ravine.	180,000	Apr. 29	Aug. 5, 1895	Dec. 16, 1895	24,600
126	McFadden	Calaveras	A. J. Mason	Mokelumne	Rock and brush dam in Buckeye Gulch.	240,000	May 27	June 17, 1895		

[a] License revoked Mar. 22, 1897.
[b] Mine worked out. License revoked May 7, 1900.
[c] Mine abandoned.
[d] Mine worked out. License revoked Apr. 23, 1900.
[e] License revoked June 25, 1900.
[f] Mine worked out. License revoked May 28, 1900.
[g] Now operated by A. Lundberg & Co.
[h] Mine worked out. License revoked May 21, 1900.
[i] Mine worked out. License revoked Apr. 16, 1900.
[j] Mine worked out. License revoked May 14, 1900.
[k] Permit refused Apr. 8, 1895.
[l] Mine abandoned. License revoked May 28, 1900.
[m] Mine worked out. License revoked May 7, 1900.
[n] Mine worked out. License revoked Apr. 30, 1900.
[o] Mine abandoned. License revoked May 21, 1900.
[p] License revoked Apr. 5, 1897.
[q] Permit refused May 20, 1895.

APPENDIX A.—*Synopsis of applications for authority to mine, with action taken thereon*—Continued.

No.	Name of mine.	County.	Name of applicant.	Mine drains into tributary of—	Nature of tailings reservoir proposed for present use.	Approximate amount of gravel proposed to mine.	Application received.	Order issued to build impounding works.	License granted.	Mined and stored previous to May 1, 1900.
						Cu. yds.	1895.			*Cu. yds.*
127	Joubert	Sierra	Frederick Joubert	Yuba	Old pits, and dams in Willow Creek.	420,000	June 3	June 15, 1895	July 15, 1895	10,000
128	Sailor Boy	do	Michael Cortez	do	Dam of Brandy City mine	20,000	do	Works already built.	Aug. 5, 1895	500
129	Plumas Imperial	Plumas	Plumas Imperial Gold Mining Co.	Feather	Rock dam in Rock Creek	120,000	June 11		July 8, 1895	42,500
130	Horse Valley	Yuba	M. V. Turner, Mrs. F. M. Brown, and Wm. Wellman.	Yuba	Brush dam in Horse Valley Creek.	12,000	do	July 16, 1895	Nov. 8, 1897	1,585
131	Youngs Hill	do	Wm. Wellman	do	Brush dams in a dry gulch	5,000	do	do		
132	Atom	do	E. C. Cochran and Charles Turner.	do	Brush dam in Williamson Creek.	70,000	do	do		
133	Galena Hill *a*	Yuba	W. R. and M. J. Williams.	do	Old hydraulic pit at Galena Hill.	84,000	do	July 15, 1895	Nov. 25, 1895	14,975
134	Tippecanoe *b*	do	Geo. Parent	do	Brush dam in Spanish Ravine.	32,000	do	do	Oct. 28, 1895	17,000
135	O'Keeffe	do	D. R. O'Keeffe	do	Closing waste cuts in hydraulic pit.	6,000	June 15	July 23, 1895		
136	Charcoal Ranch *c*	do	L. F. Fourier and John Barrere.	do	Flat adjacent to mine	150,000	do	Works already built.	July 23, 1895	812
137	Sharp	do	E. C. Kendall, J. C. Peterson, and H. Kimball.	do	Brush dam in Sharp Ravine, and old pit and reservoir.	200,000	June 24	Aug. 5, 1895		
138	Homestake	do	C. Wichman, W. Elkins, W. R. Atkinson, and B. F. Atkinson.	Feather	Dam in blind ravine	15,000	June 25	July 29, 1895	Sept. 28, 1895	2,800
139	Corkscrew *b*	Plumas	S. F. Toland and G. W. Langdon.	do	Brush dam on bank of Spanish Ravine.	25,000	June 28	Works already built.	Sept. 2, 1895	3,937
140	Last Chance	do	Henry Goering	do	Log crib dam across outlet of flat basin.	10,000	July 1	do	July 29, 1895	5,300
141	Chapelain Quartz	Yuba	James Chapelain	do	Brush dams in dry ravine emptying into Honcut Creek.	11,245,630	July 3	Oct. 14, 1895		
142	Roomie	Sierra	Luigi Lagomacini	do	Brush dam across mouth of pit.	4,600	July 5	Works already built.	July 29, 1895	
143	Big Ravine	Nevada	T. T. Kirkham	Yuba	Earth and gravel dam across old reservoir and brush dam on top of this and other dams.	6,000	July 6	Aug. 5, 1895	Dec. 7, 1896	

144	Brown Placer *d*	Sacramento	Interior Development Co.	Cosumnes	Brush and earth dams in flat ravine.	177,467	...do...	July 29, 1895	....	....
145	Cascade	Plumas	Cascade Water and Mining Co.	Feather	Log dam in Clear Creek	774,400	July 10	Sept. 22, 1895	Dec. 2, 1895	....
146	Willow Placer	Sierra	N. B. Willits and B. Pride.	Yuba	Brush and timber dam across sweeping swale.	11,000	July 20	Works already built.	Sept. 2, 1895	15,662
147	Canada *e*	...do...	Oliver F. Caya and W. T. Sherman.	...do...	Log crib dam in French Ravine.	12,000	July 26	Sept. 23, 1895	Nov. 18, 1895	42,500
148	King Sayre *c*	...do...	W. A. and M. E. Schofield.	...do...	Brush and log dam in Whisky Creek.	18,000	July 31	Works already built.	...do...	1,200
149	Argentine	...do...	Henry H. and A. A. Meyer and John Costa.	...do...	Brush dam in a basin	4,000	Aug. 6	Sept. 23, 1895	Nov. 11, 1895	9,000
150	Eureka Hydraulic *f*	Eldorado	John Pascoe	American	Brush dams in Chili Ravine.	24,400	Aug. 7	Sept. 12, 1895	Sept. 30, 1895	3,400
151	Terry Hill *g*	Plumas	E. C. Hard	Feather	Old pit stopped with stone dams.	7,480	Aug. 21	Works already built.	Oct. 14, 1895	7,386
152	Gravel Hill	Eldorado	E. D. Simpson, Gerhard Tebble, and J. A. Hunt.	American	Long dams, Gravel Hill Canyon, and natural barrier, Jones Hill Canyon.	387,000	Aug. 31	....	....	....
153	Lone Star Placer	Plumas	Will De Vinny	Feather	Gravel dam and log dam in Jackson Creek.	18,488	...do...	Works already built.	Oct. 14, 1895	46,700
154	Poormans Hydraulic. *c*	Eldorado	Charles Jordan	American	2 brush dams in Taylors Ravine.	3,023	Sept. 22	Oct. 15, 1895	Dec. 16, 1895	2,440
155	Eagle Mining Claim *h*	Amador	Lorenzo Canata and Giacomo Oneto.	Mokelumne	Brush dam in dry creek	10,300	...do...	Works already built.	Nov. 4, 1895	....
156	Jackson Creek Placer.	Plumas	Mrs. Bertha Sutton	Feather	Old pits and dams in Jackson Creek.	32,000	Sept. 28	Nov. 19, 1895	Feb. 23, 1897	7,900
157	Bobby Burns Hydraulic.	Eldorado	Henry Niedecker and George Alderson.	American	Brush dam in Johnson Creek.	40,333	Oct. 1	Works already built.	Nov. 18, 1895	....
158	Dutch *i*	Plumas	Simcoe Chapman	Yuba	Log crib dam in Rabbit Creek, and old pit.	12,000	Oct. 3	...do...	...do...	46,700
159	Lewis	...do...	Fred Lewis	Feather	Dams in old pit and Rich Gulch.	1,000	Oct. 4	...do...	...do...	1,783
160	Martin Hydraulic *b*	Eldorado	C. W. and W. W. Martin.	American	Dam in White Rock Canyon.	38,720	...do...	...do...	...do...	3,000
161	Miocene *j*	Plumas	Charles Y. Hepler	Feather	Dams in Schneider Gulch and old pit.	6,000	Oct. 8	Nov. 19, 1895	Dec. 30, 1895	....
162	Arctic	...do...	Fred Scott	...do...	Dam in Marion Creek	18,000	...do...	...do...	Oct. 26, 1896	4,750
163	Tiedeman *k*	Eldorado	Henry E. Picket	American	Brush dam in Marshall Canyon.	129,055	Oct. 11	Works already built.	Nov. 18, 1895	....
164	Chaparral Hill Gold Gravel.	Plumas	Ed. and Jas. Bryan and Aug. Fisk.	Feather	Brush and rock dam in dry ravine.	28,233	Oct. 12	Nov. 19, 1895	Dec. 16, 1895	12,786
165	Blacklock *f*	Eldorado	Eugene Piaggi	American	Dams in Taylor and another ravine.	413,000	Oct. 19	Works already built.	Nov. 18, 1895	3,780
166	Pacific	Sierra	Daniel Conlan	Yuba	Old pits; cuts stopped with dams.	4,629	...do...	...do...	...do...	....
167	Plumas Blue Gravel	Plumas	Plumas Blue Gravel Mining Co.	Feather	Old hydraulic pits	44,444	...do...	Nov. 19, 1895	Dec. 30, 1895	1,360

a Mine worked out. License revoked May 7, 1900.
b License revoked June 25, 1900.
c Mine worked out. License revoked May 21, 1900.
d Will not be worked.
e See supplemental application No. 337.
f Mine worked out. License revoked May 28, 1900.
g Now operated by W. E. Duncan, sr.
h Mine abandoned. License revoked May 28, 1900.
i Now operated by La Porte Consolidated Gold Mining Co.
j See supplemental application No. 324.
k Mine abandoned. License revoked May 7, 1900.

APPENDIX A.—*Synopsis of applications for authority to mine, with action taken thereon*—Continued.

No.	Name of mine.	County.	Name of applicant.	Mine drains into tributary of—	Nature of tailings reservoir proposed for present use.	Approximate amount of gravel proposed to mine.	Application received.	Order issued to build impounding works.	License granted.	Mined and stored previous to May 1, 1900.
						Cu. yds.	1895.			*Cu. yds.*
168	Reese *a*	Shasta	Geo. Reese	Sacramento	Brush dam in a dry ravine	500,133	Oct. 21	Nov. 26, 1895	Jan. 6, 1896	1,000
169	Ram Creek Placer *b*	Butte	J. M. Clung	Feather			...do			
170	Consolidated Sailor Creek Placer *c*	Eldorado	Geo. W. Davey	American	Log, brush, and rock dam in Irish Creek.	14,520	Oct. 25	Works already built.	Nov. 18, 1895	3,304
171	Michigan Hill *a*	Plumas	John Higgins	Feather	2 old pits stopped with brush dams, and log dam on flat ground.	15,000	Oct. 29	Nov. 19, 1895	Dec. 2, 1895	3,620
172	Manzanita *d*	Nevada	Kate Hayes Mining Co.	Yuba	Gravel and brush dams in Sweetland Creek.	1,159,604	Sept. 23	Oct. 7, 1895	Oct. 28, 1895	184,900
173	Farrel *e*	...do	Eureka Lake and Yuba Canal Co.	...do	Earth dam in worked-out pit.	111,000	Oct. 28	Works already built.	Nov. 18, 1895	59,573
174	Forest Home *a*	Amador	W. A. Roberts and John Graham.	Cosumnes	Earth and stone dam in Arkansas Creek.	1,420,000	Nov. 2	...do	Dec. 23, 1895	93,000
175	Bull Neck Gravel	...do	Jas. F. Ish	San Joaquin	Log and brush dam in blind ravine.	200,000	Nov. 8	Dec. 24, 1895		
176	Cole *e*	Eldorado	W. H. Cole	Cosumnes	Brush dam in a dry gulch	12,000	Nov. 16	Works already built.	Dec. 23, 1895	240
177	Mill Gulch Gravel *f*	Amador	H. Dickerman, John Dynan, M. Dickerman, and H. N. Dickerman, jr.	...do	...do	900	Nov. 19	Dec. 24, 1895	Mar. 30, 1896	
178	Jay Bird	Yuba	John G. Ramm	Yuba	Rock dam	12,100	Nov. 23	...do	Jan. 20, 1896	4,970
179	Wild Yankee *e*	Placer	Wm. Schilliansky, C. A. Oakes, R. W. Walter, and S. L. McKim.	American	Timber dam	100,000	Nov. 25	Dec. 16, 1895	Dec. 21, 1896	5,150
180	Badger Hill *g*	Plumas	A. B. Jacks and John Gifford.	Feather	Dam in Woods Ravine and closed cuts.	15,000	Nov. 27	Dec. 23, 1895	Jan. 13, 1896	2,935
181	Pine Leaf	...do	John Schafer	...do	Brush dam around worked-out pit.	4,000	Nov. 29	Works already built.	Dec. 23, 1895	2,300
182	Quaker Hill	Nevada	Geo. C. Sargeant	Yuba	Dams on flat ground	70,000	Nov. 30	...do	Dec. 30, 1895	
183	Meehan Placer *h*	Amador	Jas. Meehan	Mokelumne	Brush dam	217,800	Dec. 3	Dec. 24, 1895	Mar. 30, 1896	997
184	Trafton *i*	Placer	J. N. Findley	American	...do	4,000	...do	Dec. 16, 1895	...do	82
185	Irish Hill *j*	Amador	G. W. Smith	Mokelumne	Brush dam in a dry gulch	822,667	Dec. 5	Works already built.	Dec. 23, 1895	
186	Kerr *h*	Placer	Jos. G. Debons	American	Brush barriers, Devils Canyon.	2,000	Dec. 6	Jan. 13, 1896	Mar. 30, 1896	60
187	Clay Bank *j*	Plumas	Henry A. Hallsted	Feather	Log and brush barriers in flat swale.	6,500	Dec. 14	Works already built.	Jan. 13, 1896	2,500

188	Sherwood & Snyder *k*.	Tuolumne	L. M. Sherwood, W. H. Snyder, and O. E. E. Ryley.	Tuolumne	Worked-out bed of Moccasin Creek.	75,000	....do	No works necessary.	....do	....
189	Blue Gravel Placer	Amador	W. H. Glenn and J. H. Hayden.	Mokelumne	Brush dam in Rancheria Creek.	10,000	Dec. 23	Works already built.	Jan. 13, 1896	7,255
190	Emma Harding *k*	Plumas	J. F. Evans	Feather	No works necessary	2,500	....do	....	....do	....
191	Roman *k*	....do	John Smith	....do	....do	....	....do	....	....do	....
192	Kendall	Eldorado	Wiley Sexton	Cosumnes	Dogtown Creek	100	Dec. 26	Sept. 21, 1896	Dec. 21, 1896	29,000
193	Polar Star	Placer	John Spaulding	Feather	Bear River	2,000,000	Dec. 31	June 6, 1896	Mar. 14, 1898	135,700
194	Liberty Hill	Nevada	T. G. Phelps	....do	....do	144,000	1896. Jan. 2	....do	Feb. 7, 1898	70,200
195	Adkins	Shasta	Olonzo Engle	Sacramento	Brush dams in a gulch	161,334	....do	Works already built.	Jan. 20, 1896	448
196	Quong Yuck *b*	Nevada	On Sackee and Ah You.	Yuba	Log dam in Humbug Creek.	75,000	Jan. 4	....	....	....
197	Kanaka Flat	Plumas	Wm. Wampler and Solon P. Jacks.	Feather	Log dams in ravines	6,000	Jan. 7	Works already built.	Jan. 20, 1896	722
198	Couey	Shasta	G. M. Couey and W. S. Adkins.	Sacramento	Brush dams	150,000	Jan. 10	....	Mar. 17, 1896	10,036
199	Gorman	Placer	H. L. Van Eman	American	Log and brush dams in Skunk Gulch.	160,000	Jan. 13	Mar. 18, 1896	Mar. 30, 1896	....
200	Princess	Shasta	O. H. Simons	Sacramento	Crib dam in dry gulch	4,114,000	Jan. 16	....do	....do	26,350
201	Goyan *b*	Eldorado	Frank Goyan	American	Brush dam in Fish Canyon.	3,484,800	Jan. 7	Jan. 20, 1896	....	....
202	Nigger Ranch	....do	Giacomo Gianini and J. L. Poggi.	Cosumnes	Log dam	3,000	Jan. 22	Feb. 10, 1896	Dec. 21, 1896	225
203	Proper	Calaveras	John Sybel	Stanislaus	No works necessary	14,000	....do	....	Mar. 17, 1896	1,950
204	No Chunk *h*	Placer	E. S. Thompson and G. E. Hill.	American	Log dam in Skunk Gulch	....	....do	Mar. 18, 1896	Mar. 30, 1896	500
205	Kanaka Valley	Eldorado	A. J. McDonald	....do	Brush and rock dam	900	Jan. 28	Sept. 21, 1896	Jan. 3, 1898	....
206	Empire Hill	Yuba	Paris Bean	Yuba	Board and log dam	1,700	Feb. 3	....	....	....
207	Badger Hill	Eldorado	John J. Bailey	American	Pine tree dam	52,266	Feb. 17	....	....	....
208	Dark Ravine	Plumas	Mrs. Amalie Hafner	Feather	Log and brush dams in Dark Ravine.	1,000	Feb. 20	Oct. 27, 1896	Jan. 7, 1897	....
209	Grasshopper Hydraulic. *b*	Eldorado	B. Guidici	Cosumnes	2 brush dams	20,000	....do	Apr. 20, 1896	....	....
210	Miners' Row *b*	Placer	E. D. Hurd	American	Brush and log dams	48,400	Feb. 24	Apr. 6, 1896	....	....
211	Nellie Bly *e*	Shasta	Alfred A. Ludwig and Wm. Everest.	Sacramento	Log and brush dam	6,453	Mar. 17	Works already built.	Apr. 6, 1896	140
212	Duquesne Placer	Plumas	R. R. Gumbert	Feather	Log and brush dam in dry ravine.	3,000	Mar. 19	Oct. 27, 1896	....	....
213	Try Again Hydraulic *a*	Eldorado	Giacomo Varozza	American	Brush dam	4,500	Mar. 23	July 13, 1896	July 20, 1896	....
214	Ellen Taylor *a*	....do	Cy Mulkey	Cosumnes	Log and brush dam	1,209,967	Apr. 4	Works already built.	July 27, 1896	1,000
215	Phillips Claim *l*	Placer	W. Phillips	American	3 brush dams	5,000	Apr. 7	July 20, 1896	Aug. 17, 1896	390
216	Cook Gravel	Tuolumne	F. W. Eaton	Tuolumne	Log and brush dam	900,000	Apr. 14	July 27, 1896	....	....

a License revoked June 25, 1900.
b Will not be worked.
c License suspended June 4, 1900.
d License revoked Jan. 19, 1897.
e Mine worked out. License revoked May 28, 1900.
f Mine worked out. License revoked May 21, 1900.
g License revoked. Feb 14, 1898.
h Mine worked out. License revoked May 7, 1900.
i Mine worked out. License revoked Apr. 23, 1900.
j Mine abandoned. License revoked May 21, 1900.
k License revoked June 25, 1900.
l License suspended June 4, 1900.

APPENDIX A.—*Synopsis of applications for authority to mine, with action taken thereon*—Continued.

No.	Name of mine.	County.	Name of applicant.	Mine drains into tributary of—	Nature of tailings reservoir proposed for present use.	Approximate amount of gravel proposed to mine.	Application received.	Order issued to build impounding works.	License granted.	Mined and stored previous to May 1, 1900.
						Cu. yds.	1896.			*Cu. yds.*
217	Raffetto Placer	Eldorado	Giovanni Raffetto	American	Brush and timber dams	67,000	Apr. 16	Works already built.	July 20, 1896	4,080
218	Park & Browne Claim	Placer	Bernard Cavanaugh	do	2 log dams in a dry ravine	38,720	May 13	Aug. 18, 1896		
219	Deer Creek *a*	Nevada	Eber A. Sanford	Yuba	No works necessary	48,400	May 18		Nov. 2, 1896	
220	Slate Creek Placer *b*	Plumas	Henry W. Orr	Feather	2 log and brush dams	4,000	June 3			
221	Buckeye Hill Placer *c*	Eldorado	John J. Flora	American	Dam in Buckeye Canyon and flat ground.	2,000,000	June 6	Nov. 6, 1896	Apr. 26, 1897	50,590
222	California Gold Mining and Investment Co.'s Claim. *d*	Plumas	California Gold Mining and Investment Co.	Feather	Brush dam in Foreman Canyon.	30,000	June 8	No works necessary.	Oct. 26, 1896	
223	Shirley Mining Co *e*	Placer	Shirley Mining Co.	American	2 brush dams	3,780,000	June 15	Aug. 18, 1896	Jan. 11, 1897	15,550
224	Maylone Gravel *f*	Eldorado	J. R. Vandergrift	Cosumnes	Log and brush dam		June 25	Sept. 21, 1896	June 2, 1897	42,000
225	Jack's Ranch Placer *g*	Plumas	Walter Shackleford	Feather	do		July 20	Works already built.	Nov. 2, 1896	
226	Sacket's Gulch Claim	Sierra	J. F. Cowdery	Yuba	3 log crib dams	27,000	July 25	do	Nov. 16, 1896	7,440
227	Marlow	Tuolumne	A. P. Scheld	Tuolumne	Brush and rock dam	4,000,000	May 1	July 27, 1896	July 27, 1896	7,800
228	Last Chance *h*	Plumas	Fred C. DeChaine	Feather	No impounding works necessary.	90,000	June 11		Oct. 26, 1896	
229	Barnhardt	Calaveras	Cadematori & Peirano	Calaveras	Brush and rock dam	4,356,000	Aug. 5	Aug. 31, 1896	Mar. 1, 1897	16,900
230	Beattie & Parsons *i*	Eldorado	Geo. Beattie	American			Aug. 7			
231	Hilda	Sierra	Richard Phelan	North Yuba	Log and brush dam		Aug. 13	Oct. 27, 1896	Nov. 8, 1897	11,000
232	Alcyone *j*	Calaveras	W. A. Keefer	Calaveras	Dam in San Domingo Creek		Aug. 21	Sept. 15, 1896	Jan. 4, 1897	8,000
233	French Claim *k*	Eldorado	J. R. Sears	Middle Cosumnes.	Log and brush dam	250,000	Aug. 25	Sept. 22, 1896	Dec. 21, 1896	
234	Larsen Placer	do	Emil E. Larsen and John H. Harris.	American	Log dam	11,666	Aug. 28	Oct. 13, 1896	Jan. 19, 1897	4,500
235	Miocene *l*	Plumas	W. H. Leek	North Feather	Dam in Rush Creek	12,100	Aug. 31	Works already built.	Oct. 26, 1896	14,000
236	Cascajo	Calaveras	Hugh Craig	Middle Mokelumne.	Brush dam	3,872,000	Sept. 3	Oct. 13, 1896		
237	Mad Mule *j*	Shasta	John Faubel	Sacramento	Log and brush dam	200,000	do	Sept. 28, 1896	Nov. 30, 1896	
238	Blue Eyes	Placer	A. F. Sheehan	Middle American.	Log dam		Sept. 11	Nov. 23, 1896		
239	Bell & Dorsey	Eldorado	Plymouth Consolidated Gold Mining Co.	Cosumnes	Log and brush dam		Sept. 16	do	May 22, 1899	200,000
240	Gold Run *m*	Placer	E. A. Wiltsee	North American.	Log crib dam	311,000	Sept. 21	Oct. 13, 1896	Nov. 23, 1896	350,500
241	Craycroft	Sierra	H. Spaulding, et al.	Yuba	do	90,000	Sept. 24	Oct. 27, 1896		
242	Clark & Willis *n*	Calaveras	F. B. Clark	Mokelumne	Log and brush dam	60,000	Sept. 28	Nov. 17, 1896	Jan. 23, 1899	23,105
243	Albright Placer *o*	Eldorado	W. H. Albright	American	do	4,833	Sept. 30	Works already built.	Nov. 9, 1896	1,120

244	Wild Cat *c*	Nevada	Geo. W. Jones	South Yuba	Brush dam in Blind Shady Creek.	20,000	do	do	Nov. 2, 1896	7,586
245	Burlington	Sierra	John Freeman	North Yuba	Log and brush dam	20,000	Oct. 2	do	Oct. 26, 1896	9,500
246	Little Bowlder Creek	Plumas	Isaac Blomquist	Middle Feather.	do	6,000	Oct. 7	do	do	3,650
247	Eckman & Moulton *k*	Nevada	W. E. Moulton and D. W. Eckman.	South Yuba	Gravel and brush dam	177,000	Oct. 9	Nov. 2, 1896	Jan. 25, 1897	95,000
248	Hall & French *k*	do	Thos. Hall and C. D. French.	do	do	208,000	do	do	do	94,000
249	Linda Placer	Sierra	David Corbett	North Yuba	2 dams on flat	12,500	do	Works already built.	Nov. 16, 1896	4,596
250	Divide	Eldorado	Jas. E. Roelke	South American.	Brush and rock dam	6,600	Sept. 14	do	Nov. 9, 1896	4
251	Campi Placer *k*	Amador	Eckhart & Solario	Mokelumne	Log and brush dam	9,000	Sept. 17	do	Dec. 28, 1896	4,000
252	Blackwater Claim	Plumas	W. Konradi	Feather	Works of Gopher Hill Mine in Waupansie Creek.	30,000	Oct. 20	do	Nov. 16, 1896	7,607
253	Santa Clara	Amador	Em. Santirfo	Mokelumne	Log and brush dam		Oct. 21	do	Dec. 28, 1896	672
254	Cleveland Placer	Plumas	Pitro Picolo and Luigi Sobrero.	Middle Feather.	do	30,000	do	do	Nov. 16, 1896	600
255	Lady Edner	Eldorado	Chas. Edner	Middle Cosumnes.	Brush dam	1,873	Oct. 24	Nov. 9, 1896	Dec. 21, 1896	2,300
256	Grub Flat No. 2 *p*	Plumas	Walter Shackelford	North Feather	Log and brush dam	25,000	Oct. 26	Works already built.	Nov. 16, 1896	4,600
257	Sebastopol Flat	do	Francis Jackson	do	Rock and brush dam	6,000	do	do	do	424
258	Preacher's Ravine *q*	Sierra	Lamont Brown	Yuba	Log and brush dam	11,111	Oct. 22	Nov. 16, 1896	Jan. 15, 1897	3,200
259	Crawford Diggings *j*	Yuba	J. H. Nickleson and T. J. Williams.	North Yuba	do	20,000	Nov. 7	Works already built.	Dec. 7, 1896	1,000
260	Forty-nine *j*	Butte	Oregon Gold Mining Co.	South Feather	Brush dam		do	Dec. 7, 1896	Jan. 19, 1897	200
261	Bald Mountain *j*	Eldorado	Edgar Maylone	Cosumnes	Log and brush dam	2,772	do	Works already built.	Dec. 21, 1896	15,180
262	Gilbert *g*	Placer	Hoffman & McDonald	North American.	do	6,200	Nov. 9	do	Dec. 7, 1896	
263	Buckeye Hill	Nevada	Geo. W. Jones	Feather	do	16,000	Nov. 24	Dec. 7, 1896	Jan. 25, 1897	372
264	North Star *r*	Eldorado	C. W. & W. W. Martin	South American.	Brush dam	20,000	Nov. 28	Works already built.	Dec. 21, 1896	16,800
265	Bowlder Hill *j*	do	Stevens, McKinney & Co.	do	Brush and rock dam	1,000	Nov. 30	do	do	870
266	Hayden Hill	Placer	Ah Sing	North American.	Rock dam		do	Dec. 21, 1896	Dec. 28, 1896	41,872
267	Union *s*	Yuba	C. C. Beever	Yuba	Brush dam in dry ravine		Dec. 4	Jan. 5, 1897		667
268	Golden Gate	Plumas	W. H. Trescott	Feather	Log crib dam		Dec. 5	Works already built.	Nov. 29, 1897	
269	Saxton *j*	do	Dr. C. P. Saxton	do	No impounding works necessary.		do		Jan. 4, 1897	

a Mine abandoned. License revoked June 11, 1900.
b Will not be worked. No impounding facilities exist.
c License revoked May 28, 1900.
d Mine abandoned. License revoked June 4, 1900.
e Now operated by Big Gun Mining Co.
f Mine worked out. License revoked May 14, 1900.
g Mine abandoned. License revoked Apr. 30, 1900.
h Mine abandoned. License revoked June 18, 1900.
i See supplemental application No. 384.
j License revoked June 25, 1900.
k Mine abandoned. License revoked May 28, 1900.
l See supplemental application No. 324.
m Now operated by Gold Run Gravels, Limited.
n Now operated by A. L. Taylor and W. V. Clark.
o License revoked Mar. 7, 1898.
p Now operated by Henry A. Hallsted.
q Mine worked out. License revoked May 28, 1900.
r Mine now worked by ground-sluicing process. License revoked June 18, 1900.
s Working under permit of Nov. 27, 1894.

APPENDIX A.—*Synopsis of applications for authority to mine, with action taken thereon*—Continued.

No.	Name of mine.	County.	Name of applicant.	Mine drains into tributary of—	Nature of tailings reservoir proposed for present use.	Approximate amount of gravel proposed to mine.	Application received.	Order issued to build impounding works.	License granted.	Mined and stored previous to May 1, 1900.
						Cu. yds.	1896.			*Cu. yds.*
270	Sailor Flat	Nevada	O. D. Campbell	South Yuba	Log and brush dam	25,000	Dec. 7	Works already built.	Apr. 3, 1899	18,850
271	Blue Tent *a*	do	W. H. De Mott	do	do	60,000	do	do	Jan. 25, 1897	17,777
272	Frank Milan *b*	Yuba	Mathias Diehl	North Yuba	Rock and brush dam		do	Jan. 5, 1897	Feb. 8, 1897	650
273	Montre *a*	Sierra	R. M. Cunningham and Thos. Phillips.	Yuba	Brush dam in Grizzly Canyon.		Dec. 12	Works already built.	Jan. 25, 1897	3,000
274	Bell Quartz *c*	Plumas	Frank E. Thomas	North Feather	Log and brush dam		Dec. 14			
275	Cedar Creek Consolidated.	Eldorado	Cy Mulkey	Cosumnes	do		Dec. 16	Jan. 5, 1897		
276	Lucot *b*	Amador	Samuel D. Robinson and Al. Petty.	do	do	2,500	Dec. 28	Works already built.	Jan. 4, 1897	2,000
							1897.			
277	Drummondsville	do	S. J. Holsinger	do	Brush dam		Jan. 5	Jan. 25, 1897	Mar. 22, 1897	4,600
278	Pebble Bottom *d*	Placer	G. D. Duncan & Co.	North American.	Log and brush dam	33,333	Jan. 7	do	Feb. 8, 1897	350
279	Woodpecker Placer	Butte	D. Egmon	South Feather	Brush dam	15,000	Jan. 8	Works already built.	Feb. 1, 1897	2,915
280	Big Chunk	Eldorado	John C. Murphy	South American.	Log and brush dam	2,420	Jan. 9	do	do	950
281	Hawkeye *d*	Amador	Henry Whitehead & Co.	Mokelumne	Brush dam	17,000	Jan. 20	do	do	840
282	Irish Hill	do	Geo. W. Hadley	Cosumnes	do		Jan. 18	do	do	1,150
283	Frazer Placer *e*	Calaveras	J. B. Leonardini	Calaveras	Brush dam in Old Gulch		Jan. 28	Feb. 15, 1897	Mar. 1, 1897	702
284	Zugar & Lewis *f*	do	J. W. Zugar	do	do		do	do	do	2,608
285	High Point	Yuba	Thos. Mullin	Middle Yuba	Log and brush dam		do	do		
286	Kentucky Hill	Sierra	Chas. Weiss	do	do		do	do	Mar. 29, 1897	1,000
287	Roberts & Co	Yuba	A. F. Roberts	Yuba	Rock and earth dam	1,700	Feb. 1	Works already built.	Feb. 15, 1897	550
288	Sugar Loaf	Placer	Ed Gray and John Taylor.	South Yuba	2 brush dams		Feb. 2	do	do	1,280
289	Smith's Flat	Plumas	Wampler & Jacks	Feather	Log and brush dam	5,000	Feb. 10	Aug. 24, 1897		
290	Sunny South *g*	Eldorado	E. Williamson & Co.	Middle Cosumnes.	do	150,000	Feb. 17	Works already built.	Mar. 8, 1897	7,628
291	Jones & Humphreys *h*	Yuba	Dave Humphreys and R. R. Jones.	North Yuba	do		Feb. 19			
292	Hall's Flat	Butte	B. P. Crandall	North Feather	2 old pits below mine		Feb. 12	Feb. 23, 1897	Mar. 1, 1897	396
293	Annie Laurie	Placer	Geo. Nissen	North American.	Brush and rock dam	15,000	Mar. 9	Mar. 29, 1897	Jan. 24, 1898	559
294	Alameda	do	Frank Wise and Martin Partridge.	do	do	50,000	do	Works already built.	Mar. 29, 1897	5,200

295	Philadelphia	Tuolumne	T. C. Cox and W. C. Pidge.	Stanislaus	Log and brush dam	31,600,000	Mar. 13	Aug. 2, 1897	Mar. 19, 1900	800
296	Little Grass Valley *i*	Nevada	T. G. Curnow et al	Yuba	Rock and brush dam	3,000	Mar. 29	Works already built.	Apr. 19, 1897	
297	Galena Hill *j*	Yuba	Morris J. Williams et al	do	Brush dams	3,000	Apr. 6	do	May 3, 1997	625
298	Hustler No. 2 *k*	Nevada	Jos. Hustler	do	do	9,000	Apr. 12			
299	Howlett	do	Chas. and Ben Howlett.	do	Log and brush dam	10,000	Apr. 19	May 10, 1897	Jan. 24, 1898	280
300	Marguerite *l*	do	Marguerite Gravel and Quartz Mining Co.	do		15,000	Apr. 21			
301	McGregor & Nix *m*	Butte	Wm. McGregor and C. F. Nix.	Sacramento	Impounding works of Spring Valley Mine.		Apr. 23			
302	Industrial *n*	Eldorado	Industrial Gold Mining Co.	Cosumnes	Log and brush dam	1,500	May 3	Works already built.	May 24, 1897	500
303	Messerer *o*	Plumas	James Rooks	Feather	do	1,000	May 5	Aug. 23, 1897	Oct. 25, 1897	300
304	Costa & Davis Mining Co.	Butte	John Costa and Frank Davis.		Worked-out pit	10,000	May 8	May 24, 1897	do	1,550
305	Haskel Ravine	Sierra	Haskel Ravine Mining Co.	Feather	Log and brush dam	14,000	May 11	July 26, 1897		
306	Parsons	Eldorado	Hoey & Lewis	Cosumnes	do	200,000	May 22	June 14, 1897	Oct. 11, 1897	4,200
307	Morristown	Sierra	Daniel McLaughlin	Yuba	do	10,000	May 24	July 26, 1897		
308	Etta	do	Henry Northrop and Robert C. Nicholson.	do	Log and rock dam	444	May 26	do		
309	May Flower *d*	Placer	May Flower Gravel Mining Co.	American	Log crib dam	4,000,000	May 28	Sept. 14, 1897	Jan. 24, 1898	20,956
310	Pactolian *h*	Plumas	Dr. J. P. Welch	Feather	Brush dam	64,500	June 1			
311	Mountain View	Butte	J. P. West	do	do		May 26	June 28, 1897	Feb. 20, 1899	7,800
312	Gold Bug	Eldorado	Gold Bug Mining Co.	American	Brush and log dams	635,550	July 1	Aug. 9, 1897	Dec. 20, 1897	16,000
313	Eclipse & Boston	Plumas	E. D. Bowman et al	Feather	Log crib dam		July 10	Aug. 24, 1897	Nov. 29, 1897	7,200
314	King Bird	Yuba	E. H. Adams	do	Log and brush dam	7,000	July 21	Sept. 13, 1897	Feb. 28, 1898	
315	Fratus & Foster	Butte	John Fratus and Manuel Foster.	Sacramento			July 28			
316	Lost Camp	Placer	J. T. Coffman and G. T. Miller.	American	Log and brush dam	400,000	Aug. 13	Works already built.	Sept. 13, 1897	4,600
317	Washington	Sierra	Mrs. E. A. Cox	Feather	Log dam	80,000	Aug. 20	Sept. 13, 1897	Feb. 28, 1898	15,300
318	Willow Placer Extension.	do	N. B. Willits et al	Yuba	do	25,000	Sept. 1	Works already built.	Jan. 3, 1898	25,400
319	California	do	G. A. Rosenthal, Jas. Cosgrove, and Wm. Costigan.	North Yuba	do	8,000	Sept. 7	do	Nov. 8, 1897	200
320	Hallsted Placer	Plumas	H. A. Hallsted	Feather	do	20,000	Sept. 8	do	Nov. 29, 1897	1,500
321	Schneider Diggings	do	Jacob Yager	do	do	20,000	do	do	Oct. 25, 1897	
322	Taber Gold *i*	Sierra	Horace Taber	Yuba	do	10,000	Sept. 10	do	do	1,890
823	Black Oak	Placer	Fred Smith	American	Log and brush dam	10,740	Sept. 14	Oct. 19, 1897	Jan. 24, 1898	

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f License revoked June 11, 1900.
g Mine abandoned. License revoked May 28, 1900.
h Mine abandoned.
i License revoked May 28, 1900.
j Mine worked out. License revoked May 7, 1900.
k Authorization of proposed impounding works refused May 3, 1897.
l Permit refused July 26, 1897.
m Permit refused May 10, 1897.
n Mine worked out. License revoked Mar. 26, 1900.
o Now operated by McElroy & Gordon.

APPENDIX A.—*Synopsis of applications for authority to mine, with action taken thereon*—Continued.

No.	Name of mine.	County.	Name of applicant.	Mine drains into tributary of—	Nature of tailings reservoir proposed for present use.	Approximate amount of gravel proposed to mine.	Application received.	Order issued to build impounding works.	License granted.	Mined and stored previous to May 1, 1900.
						Cu. yds.	1897.			*Cu. yds.*
324	Miocene	Plumas	W. H. Leek et al	Feather	Log and brush dam	50,000	Sept. 15	Works already built.	Nov. 15, 1897	18,650
325	Ellrig *a*	Amador	Henry Coubrough	Cosumnes	do	193,600	Sept. 16	Nov. 2, 1897	Dec. 20, 1897	2,080
326	Slate Creek	Eldorado	John C. Murphy	American	do	4,840	do	Oct. 11, 1897	do	
327	Jamison Placer	Plumas	John M. Jackson	Feather	Log dam	15,000	do	Works already built.	Dec. 27, 1897	570
328	Barnard's Diggings	do	Fook Hing Lung	Yuba	Log crib dam	10,000	Sept. 20			
329	Jupiter Gravel *b*	Calaveras	Jupiter Gravel Mining and Water Co.	Calaveras	do	50,000,000	Sept. 24	Nov. 2, 1897	Jan. 17, 1898	161,000
330	Spanish Bar *c*	do	Howard Rule	Mokelumne			Sept. 29			
331	Grizzly Canyon *d*	Sierra	Victor Montre	Yuba	Brush dam		do	Nov. 8, 1897	Jan. 24, 1898	770
332	Homestake No. 2	do	B. F. Atkinson et al	Feather	do	25,000	do	Works already built.	Oct. 11, 1897	100
333	Emerton	do	Sam Ahtye	North Yuba	Log dam	5,000	do	do		
334	Doherty	do	do	do	Log crib dam	16,000	do	Oct. 26, 1897		
335	Gold Nugget	do	C. R. Scott et al	do	do	15,000	Oct. 1	Works already built.	Nov. 29, 1897	2,120
336	Sackets Gulch	do	J. F. Cowdery	Yuba	Brush dam	25,000	Oct. 6	do	Nov. 15, 1897	2,700
337	Canada	do	W. T. Sherman and O. F. Caya.	North Yuba	Log crib dam	4,000	Oct. 15	do	Nov. 29, 1897	
338	Mosquito *e*	Yuba	R. Cordez	Yuba	Brush dam		Oct. 19	Nov. 8, 1897	Jan. 24, 1898	75
339	Montalgo *f*	Eldorado	C. N. Foote	Cosumnes	Stone dam	1,750	Oct. 21	Works already built.	Jan. 17, 1898	
340	Richardson Ranch	Shasta	Santa Clara Mining Co	Sacramento	Irrigating dam		Oct. 11	do	Nov. 8, 1897	615
341	Conrad & Wheeler	Butte	T. Larimore	Feather	Log and brush dam	10,740	Oct. 26	do	Nov. 29, 1897	400
342	Manuel Silva Mining Co.	do	Manuel Silva and J. Enos.		Brush dam		Nov. 8			
343	Mohler *g*	Sierra	Geo. W. Mohler	Yuba	Log and brush dam		Nov. 11	Nov. 29, 1897	Jan. 24, 1898	5,400
344	Round Butte	Calaveras	E. C. Rigney	Calaveras	do	600,000	Oct. 26	Nov. 8, 1897	Dec. 20, 1897	14,250
345	Cambridge *f*	Amador	D. D. Allard et al	Cosumnes	do	160,000	Nov. 11	Dec. 20, 1897	Jan. 17, 1898	1,500
346	Manzanita *h*	Nevada	Kate Hayes Mining Co	Yuba	Impounding basin of Manzanita mine.		Nov. 1	Jan. 10, 1898	Mar. 28, 1898	55,350
347	Colfax Gravel and Pierce.	Placer	J. H. Kneeland, jr	American	Log and brush dam		Nov. 8	Works already built.	Feb. 7, 1898	700
348	American Gravel *i*	Butte	L. L. Sherrod et al	Sacramento	Log crib dam		do	Dec. 20, 1897	do	3,025
349	Sunshine	Sierra	Thos. Wayman	Yuba	do	10,000	Nov. 18	do	Jan. 24, 1898	4,037
350	Grizzly *g*	do	Geo. Standart	do	Brush dam	5,000	do	Works already built.	do	110
351	Red Dog *j*	Nevada	John Spaulding	Bear	Log crib dam		Nov. 22	Jan. 10, 1898	Feb. 21, 1898	69,400
352	Red Hill *g*	Placer	A. A. Pond	American	Log and rock dam		Nov. 24	Works already built.	Jan. 3, 1898	3,875

353	Ralph Farnham	Eldorado	Ralph Farnham	Cosumnes	Log and brush dam		....do	....do	Dec. 20, 1897	6,950
354	Badger Hill	....do	Geo. Rieber	American	....do		Nov. 26	....do	Dec. 27, 1897	
355	Try Again Placer	....do	F. W. Cook	....do	....do	180,000	Nov. 28	....do	Jan. 3, 1898	25,000
356	Hoosier *d*	....do	Matt Yoner	....do	Dam on Bear Creek	1,500	Dec. 1	....do	Jan. 31, 1898	
357	Mountain Ranch	Calaveras	Otto Reichel	Calaveras	Rock dam		....do	....do	Feb. 14, 1898	
358	Johnston Placer	....do	W. H. Johnston et al	....do	Log crib dam		Dec. 2	Dec. 27, 1897		
359	McMartin	Plumas	W. C. Corbett and A. W. Carmichael.	Feather	Impounding works of Good Hope mine.	50,000	Nov. 25	Works already built.	Nov. 29, 1897	2,900
360	Chris Limpher *k*	Amador	W. N. Lamb and J. G. Underwood.	Cosumnes	Log and brush dam	96,000	Dec. 6	Dec. 27, 1897	Jan. 17, 1898	700
361	Frazzer & Swank	Calaveras	B. Freccero	Calaveras	Stone dam		Dec. 11	Jan. 17, 1898	Mar. 28, 1898	796
362	Cherokee Flat	Butte	Manuel Silva and J. Enos.		Brush dam		Dec. 13			
363	Grizzly Bear	Plumas	J. Lagomasino	Feather	Log and brush dam	7,000	Dec. 15	Works already built.	Jan. 17, 1898	1,225
364	Last Chance	Sierra	Paul Zerga et al	Yuba	Rock, brush, and log dams	29,000	Dec. 17	Nov. 29, 1898		
365	Mount Vernon	Nevada	T. T. Kirkham	....do	Rock dam	4,000	Dec. 20	Works already built.	Jan. 24, 1898	1,320
366	Clark	Amador	Wm. Ross	Mokelumne	Rock and brush dam	10,000	Dec. 21			
367	White Oak *l*	Placer	Chas. E. Wise	American	Brush dam	8,000	....do	Works already built.	Jan. 24, 1898	2,098
368	Red Gulch and Mahala Flat Hill.	Amador	John Solari and Joe Devencenzi.	Mokelumne	....do	11,000	Dec. 22	....do	Jan. 17, 1898	107
369	Bicknell	....do	J. F. and M. A. Goodman.	....do	....do		....do	....do	....do	266
370	Indiana and Gold Bug	Eldorado	S. R. Hackley	Cosumnes	Log and brush dam	100,000	Dec. 23 1898.	....do	Jan. 31, 1898	880
371	Murphy Diggings	Amador	O. M. Henry	Mokelumne	Log dam	5,900	Jan. 5	....do	Feb. 7, 1898	550
372	Clap Board Gulch	....do	Geo. A. Gritton	....do	....do	1,112	Jan. 6	....do	....do	
373	Cox	Eldorado	Frank J. Goyan	American	Log and brush dam		Jan. 11	....do	Oct. 10, 1898	2,661
374	Hull Placer	Plumas	J. M. Longnecker	....do	Log dam	50,000	Jan. 13	Mar. 28, 1898		
375	Homestake *m*	Amador	E. Becker and Robert Mooney.	Mokelumne	Brush dam	16,000	Jan. 20	Works already built.	Feb. 21, 1898	580
376	Croff *k*	....do	W. N. Lamb	Cosumnes	....do	235,200	Jan. 25	....do	Feb. 28, 1898	
377	Long Ravine	Nevada	B. F. Steese and O. Woehler.	Feather	Stone dam	106,700	Jan. 27	Feb. 28, 1898	Nov. 28, 1898	633
378	Amo *n*	Butte	J. W. Cummins	....do	Log crib dam	4,000,000	....do	Mar. 21, 1898	Nov. 21, 1898	3,331
379	Green Mountain	Calaveras	John E. Burton	Calaveras	Rock dam		Feb. 8	Mar. 28, 1898	Nov. 7, 1898	8,000
380	Harville	Eldorado	Harville Mining Co	Cosumnes	Brush dam	508,000	Mar. 8	Works already built.	Oct. 10, 1898	
381	Badger Hill	Plumas	A. B. Jacks	Feather	Log dam	2,700	Mar. 9	Apr. 3, 1899		
382	Star of Plumas	....do	Star of Plumas Water and Mining Co.	....do	Log crib dam		Mar. 10	Nov. 29, 1898	Apr. 8, 1899	
383	Auriole	Amador	Wm. Nolden	Cosumnes	Log dam	60,000	Mar. 21			
384	Beattie	Eldorado	Geo. Beattie	American	Dam of Gold Bug mine	600	Mar. 23		Dec. 27, 1898	1,411
385	Blue Rock	....do	Geo. C. Rau	....do	....do	6,000	Apr. 4		....do	

a Mine worked out. License revoked May 7, 1900.
b Now operated by San Domingo Gold Mining Company.
c License refused October 11, 1897.
d License revoked May 28, 1900.
e License revoked May 7, 1900.
f License revoked June 25, 1900.
g Mine worked out. License revoked May 28, 1900.
h License suspended April 16, 1900.
i Now operated by S. Pomeroy and J. Wyllie.
j License revoked May 28, 1900. New application made by other parties.
k License revoked June 4, 1900.
l Mine abandoned. License revoked May 28, 1900.
m Mine worked out. License revoked June 4, 1900.
n Now operated by G. W. Rumble.

APPENDIX A.—*Synopsis of applications for authority to mine, with action taken thereon*—Continued.

No.	Name of mine.	County.	Name of applicant.	Mine drains into tributary of—	Nature of tailings reservoir proposed for present use.	Approximate amount of gravel proposed to mine.	Application received.	Order issued to build impounding works.	License granted.	Mined and stored previous to May 1, 1900.
						Cu. yds.	1898.			Cu. yds.
386	Driesbach & Dudley *a*	Nevada	Driesbach & Dudley	Yuba	Log and brush dam	4,000	Apr. 4	Apr. 4, 1898		
387	Fair View *b*	do	Wm. E. Moore and John Isbister	do	do	57,870	Apr. 8			
388	Imperial	Sierra	David Cabona	do	Log and brush barriers on flat		Apr. 25	Nov. 28, 1898		
389	Pemberton Gravel	Placer	Sara E. Reamer	American	Log and brush dams	481,000	June 10			
390	Bull Run Placer	Nevada	Grant Penrose and William Harker.	South Yuba	Log and brush dam	500,000	June 15	Sept. 18, 1899	Nov. 13, 1899	4,282
391	Excelsior *c*	do	Excelsior Mining Co.	Feather	Log dam	2,000,000	Sept. 13	Dec. 19, 1898	Jan. 31, 1899	6,500
392	Fair Play	Sierra	Toy Kee	Yuba	Log crib dam	30,000	Oct. 19	Nov. 7, 1898	May 1, 1899	14,000
393	Gravel Hill *d*	Nevada	S. F. Bullard and A. M. Gray.	do	do	700,000	do	do	Jan. 23, 1899	37,000
394	Plumas Bonanza	Plumas	Elmore Rutherford	Feather	Log and brush dam	4,000	do			
395	Hangmans Gulch *e*	Eldorado	Geo. W. Allen and E. P. Thomas.	American	2 brush dams	1,000	Oct. 22	Works already built.	Nov. 28, 1898	511
396	Sampson	Sierra	Lusk & Millar	Feather	Log barriers	150	Oct. 28	Dec. 19, 1898	June 19, 1899	
397	Morristown	do	E. Reynolds and F. Carter.	Yuba	Log crib dam	20,000	Oct. 31	Nov. 28, 1898		
398	Meyers Placer	Eldorado	Geo. D. H. Meyers	American	Brush dam	77,440	Nov. 3	Works already built.	Nov. 28, 1898	700
399	Corsica	Sierra	Frank and Antone Leveroni.	Yuba	Log and rock barriers	15,000	Nov. 7	Nov. 28, 1898		
400	Wintz	Eldorado	Wintz Mining and Improvement Co.	Cosumnes	Brush dam	15,000	Nov. 15	Dec. 12, 1898	Jan. 30, 1899	1,000
401	Cleveland No. 2 *f*	Sierra	Joel Bean	Yuba	Log crib dam	50,000	Nov. 16	Works already built.	Dec. 12, 1898	5,237
402	Haskell Valley	Plumas	J. B. Jones	Feather	Log and brush dam	10,000	Nov. 17	Dec. 12, 1898		
403	Snowy Side	do	Thos. Gomez	do	Log crib dam	20,000	do	do	Aug. 14, 1899	5,000
404	New York	do	N. H. Friis	do	do	12,000	do	do	do	700
405	Chaplain	do	J. C. Horner	do	do	4,000	do	do	do	
406	Rocky Bar	do	Llewellyn A. Hoeflich	do	Worked-out pits	24,000	Nov. 21	do		
407	Oriole Gravel	Tuolumne	C. W. Ayers	Tuolumne	Brush dam		Nov. 23	do		
408	Humbug Gulch	Amador	Rocco Molinari	Mokelumne	do	4,800	Nov. 25	Works already built.	Jan. 16, 1899	15
409	Grizzly Hill	do	J. B. Meek	do	do	4,000	Dec. 15	do	do	101
410	Emery Placer	Calaveras	Lewis Emery, jr	Calaveras	Log crib dam	600,000	do	Jan. 23, 1899	Apr. 24, 1899	67,360
411	Newell Claim	Amador	Archie Newell	Mokelumne	Brush dam	5,600	Dec. 21	Works already built.	Jan. 16, 1899	
							1899.			
412	Silver Star Flume and Mining Co.	Plumas	S. S. Taylor	Feather	Worked-out pit	30,000	Jan. 4	do	Mar. 20, 1899	2,122
413	Bonanza Claim	Amador	H. S. Byam	Cosumnes	Brush and earth dam	600,000	Jan. 7	Feb. 1, 1899	Mar. 13, 1899	26,300

414	Badger Hill	Nevada	Badger Hill and Cherokee Gravel Mining Co.	Yuba	Worked-out pit	500,000	Jan. 12	Feb. 13, 1899	June 12, 1899	186,100
415	Cedar Creek	Eldorado	F. M. Phelps	Cosumnes	Brush and earth dam	15.000	Jan. 16	Mar. 13, 1899		
416	Badger Hill	Plumas	A. B. Jacks	Feather	Old pits	270	Feb. 1	Apr. 3, 1899		
417	Hoads Ranch	Butte	John H. Hoad	do	Log dam	5,000	Feb. 4	Aug. 14, 1899		
418	Mountain Ranch	Calaveras	J. S. Mills	Calaveras	Log crib dam	363,000	Feb. 6	Feb. 27, 1899	Dec. 11, 1899	3,725
419	Doherty	Sierra	Hong Fat Co	Feather	do	70,000	Feb. 23	Mar. 20, 1899	Apr. 3, 1900	2,000
420	Santa Cruz	Plumas	D. M. Butterfield	do	Worked-out pit	700	do	do	May 1, 1899	1,045
421	Spanish Flat	do	Sam Ahtye	Yuba	Rock and brush dam	42,000	Feb. 24	do		
422	Dry Creek *g*	Yuba	J. D. Wetmore and Martin Tufford.	do	Dam of Forbestown Ditch Co. in Dry Creek.		Mar. 1			
423	Gold Bug *h*	Butte	E. H. Adams	Feather	Brush dam	2,000	Mar. 21	Works already built.	May 15, 1899	200
424	Santa Rosa Placer	Plumas	John McCollum	do	Log and brush dam	3,000	Apr. 18	do	June 12, 1899	200
425	Yankee Hill	do	Plumas Development Co.	Yuba	Log crib dam	8,349	Apr. 24	do	May 15, 1899	2,000
426	North Hill	Calaveras	J. H. Southwick	Calaveras	Earth dam	1,000,000	May 1	June 12, 1899		
427	Ohio Placer	Plumas	T. B. Bennett	Feather	Log and brush dam	14,000	May 6	Works already built.	June 12, 1899	142
428	York Ranch Placer	do	W. E. Duncan, sr	do	Log and brush dams inclosing flat.	50,000	May 11	June 12, 1899	Jan. 2, 1900	
429	Klondike	Sierra	Alfred Schofield	Yuba	Impounding works of Washington Mine.	16,000	May 17		June 12, 1899	1,000
430	Clinton Placer	Amador	H. W. Tangerman	Mokelumne	Log and brush dam	65,000	June 24	July 31, 1899	Aug. 14, 1899	900
431	Birdseye Creek Placer	Nevada	J. S. Goodwin	Bear	Old reservoir	173,000	Aug. 5	Sept. 18, 1899	Oct. 16, 1899	133,707
432	Klondike	Sierra	Mrs. E. A. Cox	Feather	Brush dam	6,000	Aug. 10	Oct. 2, 1899		
433	Red Hill Gravel	Eldorado	Geo. W. Stone and Jas. J. Sherwick.	American	One log crib dam and one brush and log dam.	30,000	Aug. 11	Sept. 4, 1899		
434	Badger Hill	Plumas	A. B. Jacks	Feather	Log and brush dam	700	Aug. 25			
435	Smiths Blue Gravel	Shasta	John O. Smith, J. Devenport, and Don Noble.	Sacramento	Worked-out pit	20,000	Sept. 8	Works already built.	Oct. 9, 1899	21,348
436	French Claim	Sierra	Henry H. Meyer et als.	Yuba	Brush dam in dry ravine		Sept. 25			
437	Hopkins Creek Tailing and Bank Mines.	Plumas	R. J. Sinnott and F. M. Spencer.	Feather	Log crib dam	12,000	Oct. 2	Oct. 30, 1899		
438	Eagle Gulch	Butte	Jas. C. West	do	Rock and brush barriers inclosing flat.	3,611	Oct. 4	Apr. 2, 1900		
439	Landecker	Eldorado	W. H. Secombe	American	Brush dam	2,500	Oct. 27	Dec. 4, 1899	Jan. 22, 1900	1,675
440	Paragon	Placer	Jos. J. Hoffman and T. M. Browne.	do	Stone barriers	96,000	Oct. 28	Works already built.	Dec. 11, 1899	15,600
441	Pebble Hill	Eldorado	G. W. Coates and E. S. Randall.	do	Log and brush dams	16,000	Nov. 13	do	Dec. 18, 1899	6,430
442	Sydney Flat Gravel	Tuolumne	B. F. Keith and J. and Wm. Gannon.	Tuolumne	Worked-out pits	31,000	Nov. 18	Dec. 26, 1899		
443	Consolidated Placer	Nevada	Eureka Lake and Yuba Canal Co., Consolidated.	Yuba	Log crib dam	88,750	Nov. 20	Feb. 19, 1900	June 18, 1900	

a Will not be worked by hydraulic process.
b Mine abandoned.
c Now operated by Excelsior Point Mining Co.
d License suspended May 28, 1900.
e Mine worked out. License revoked May 28, 1900.
f License suspended April 2, 1900.
g Mine abandoned.
h Mine worked out. License revoked May 28, 1900.

APPENDIX A.—*Synopsis of applications for authority to mine, with action taken thereon*—Continued.

No.	Name of mine.	County.	Name of applicant.	Mine drains into tributary of—	Nature of tailings reservoir proposed for present use.	Approximate amount of gravel proposed to mine.	Application received.	Order issued to build impounding works.	License granted.	Mined and stored previous to May 1, 1900.
						Cu. yds.	1899.			*Cu. yds.*
444	Chalk Flat	Sierra	F. M. Thomasson	Yuba	Brush dams		Nov. 22	Works already built.	Mar. 19, 1900	200
445	Boire Placer	Calaveras	Walter Boire	Mokelumne	Earthen dam	4,749	...do	Dec. 26, 1899	Mar. 12, 1900	1,500
446	Coffee Pot Ravine *a*	Yuba	Paris Bean	Yuba	Log and brush dam		Nov. 27			
447	Little Gap	Tuolumne	J. W. Pinder	Merced	Log crib dam	250,000	...do	Dec. 26, 1899	May 28, 1900	
448	Ben Franklin and Davis, Consolidated.	Placer	J. M. Gilbert and A. M. Colwell.	American	Worked-out pit		Dec. 1	Apr. 2, 1900		
449	Williams Ranch	Shasta	Jos. Williams, Geo. Mitchell, and John O. Smith.	Sacramento	Log and brush dam	2,920	Dec. 5	Dec. 26, 1899		
450	Southern Cross	Placer	O. W. Henderson, Wm. McCoy, and Chas. D. Lowell.	American	Log and brush and rock and brush dams.	10,000	...do	Works already built.	Apr. 2, 1900	
451	Riffle Point	Sierra	Chas. L. Diesem	Yuba	Brush dams	9,270	Dec. 11			
452	Lucky Point	...do	J. F. Cowdery	...do	Brush barriers	20,833	...do	Works already built.	Mar. 26, 1900	
453	Cherokee	Butte	A. W. Mellon et als	Sacramento	Earthen dam faced with brush.	2,000,000	Dec. 4	Jan. 5, 1900		
454	Inskip Placer	Placer	E. A. Moody	Bear	Log crib dam	100,000	Dec. 21	Works already built.	Apr. 30, 1900	
455	Weeds Point	Yuba	Morris J. Williams	Yuba	Log and brush dams	1,000	Dec. 20			
							1900.			
456	Red Dog *b*	Nevada	Red Dog Mining Co. and South Yuba Water Co.	Bear	Log crib dam	250,000	Jan. 16			
457	Badger Hill	Plumas	A. B. Jacks	Feather	Log and brush dam	1,300	Jan. 2			
458	Union	Yuba	Manuel Leal	Yuba	Dam of the Nevada Co. at New York Flat.	5,200	Jan. 25	Works already built.	Mar. 26, 1900	45
459	Manila	Shasta	Walter E. Peterson	Sacramento	Brush dam	50,000	Jan. 27	...do	...do	2,500
460	Cherokee Gravel	Tuolumne	Cherokee Gravel and Gold Mining Co.	Tuolumne	Log crib dam	100,000	Feb. 5	Mar. 19, 1900		
461	Hedrick Gravel	Calaveras	Geo. H. Hedrick	Calaveras	Brush dam with stone foundation.	5,000	Mar. 2	Mar. 12, 1900		
462	Red Dog	Nevada	Red Dog Mining Co. and South Yuba Water Co.	Bear	Log crib dam	250,000	Mar. 5			
463	Weyman Placer	Eldorado	Wm. Weyman	American	Basin inclosed by embankment.	15,000	Mar. 6	Works already built.	May 7, 1900	
464	Emery Hydraulic	Claveras	Lewis Emery, jr	Calaveras	Log crib dam	650,000	Mar. 14		Apr. 23, 1900	

465	Greenhorn	Nevada	Henry Meyer	Yuba	Worked-out pit	5,000	Mar. 12		Apr. 2,1900	
466	Pigeon Creek	Amador	Hugh H. Crain	Cosumnes	Brush dam	3,000	...do	Works already built.	...do	
467	Bowlder Hill	Eldorado	Martin Klein	American	...do		Mar. 23	...do	Apr. 30,1900	
468	Little Klondyke	...do	G. E. Volmer	...do	Impounding works of Weyman Placer mine.	35,000	Apr. 3	...do	May 7,1900	
469	Bluff Placer	Calaveras	E. W. Hayden	Calaveras	Brush dams	10,000	Apr. 12			
470	Gardners Point	Sierra	Robert Hill	Yuba	Log crib dam	800	Apr. 24			
471	Dry Gulch Placer	Eldorado	Chas. Hilton	Cosumnes	...do	2,000,000	May 23	June 11,1900		
472	Golden Hill	Butte	Golden Hill Mining Company.	Sacramento	...do	3,840,000	May 24	June 25,1900		
473	Gold Run Placer	Plumas	F. E. Thomas	Feather	Log and brush dam	100	June 8			
474	Deadwood Hill	...do	Walter C. Robinson	...do	Log crib dam	44,000	June 21			

a Application withdrawn March 26, 1900.

b Application withdrawn. New application submitted. See No. 462.

PROTECTION OF SACRAMENTO AND FEATHER RIVERS, CALIFORNIA.

[Printed in House Doc. No. 431, Fifty-sixth Congress, first session.]

OFFICE OF THE CHIEF OF ENGINEERS.
UNITED STATES ARMY,
Washington, February 10, 1900.

SIR: I have the honor to submit herewith a report, dated January 30, 1900 (with maps[1]), by the California Débris Commission, containing a project, together with an estimate of cost of same, for construction of certain works for the protection of the Sacramento and Feather rivers from injury by mining or other débris. The project is submitted in accordance with the requirements of act of Congress approved March 1, 1893, creating the California Débris Commission, a copy of which is attached to the report, and the item in the river and harbor act of June 3, 1896, appropriating $250,000 for the purpose indicated.

Exhaustive study has been given by the Commission to the subject of successfully impounding mining débris to prevent further injury to navigable waters in California from this cause, and the Yuba River has been selected as the site for the first works to be constructed for the reason that it carries more detritus than all the other tributaries of the Sacramento River combined. The project now presented contemplates, primarily, the storage of mining débris within the bed of the Yuba River by a system of works designed to separate the coarse material from the fine; and, secondarily, the restriction of the low water channel within narrower well-defined limits in order to preserve in place the extensive deposits in the river below. The objects sought are to be accomplished by (1) the construction of four restraining barriers and a settling basin in the bed of the river, the structures to be provided with necessary weirs and conduits to regulate the inflow and outflow of water, and to cause a deposition of the finer material carried in suspension; (2) the construction below the settling basin of training works necessary to confine the river within well-defined lines.

The estimated cost of this work is $800,000, which includes the price of land needed (about 2,000 acres).

The Commission believes the project practicable and worthy, and recommends its adoption; and especial attention is invited by it to the fact that the object sought to be accomplished is the storage of the detritus now in the Yuba and its tributaries, with a view to the improvement of the rivers below, and decidedly not with the view of permitting unlicensed or indiscriminate hydraulic mining at localities above the impounding works.

The views and recommendations of the Commission are the result of careful study and investigation for a period of over five years, and I recommend approval of the project submitted, which is stated to be to a certain extent experimental.

It is suggested that an opinion be obtained from the proper law officer of the Government on the following points concerning which the Commission asks advice, viz, whether payment for necessary land for impounding works can be made from the appropriation made by the river and harbor act of June 3, 1896, and whether the proposed work can be commenced unless available funds are sufficient to complete the same, reference being had to the item in the river and harbor act of March 3, 1899, which provides—

That the Secretary of War, in carrying out the provisions of any act of Congress providing for the restraining or impounding of mining débris in California, may, in

[1] Not reprinted. Printed in House Doc. No. 431, Fifty-sixth Congress, first session.

his discretion, when in his judgment the aggregate of appropriations already made by said State and Congress and available therefor are sufficient to complete the same, undertake the works necessary thereto. * * *

The estimated cost of work proposed is $800,000, and the amount available is $500,000, of which $250,000 was appropriated by Congress and $250,000 by the State of California.

Copies of United States and State laws on the subject are attached to the report of the Commission.

A copy of the report is herewith, and I recommend that it be transmitted to the Speaker of the House of Representatives for the information of Congress.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Hon. ELIHU ROOT,
Secretary of War.

PROJECT FOR IMPOUNDING MINING DÉBRIS IN THE YUBA RIVER, CALIFORNIA, WITH A VIEW TO THE IMPROVEMENT OF NAVIGATION IN THE SACRAMENTO AND FEATHER RIVERS.

CALIFORNIA DÉBRIS COMMISSION,
San Francisco, Cal., January 30, 1900.

GENERAL: The California Débris Commission has the honor to submit a report, with project, estimate of cost, and maps, on the subject of impounding mining débris in the Yuba River, California.

The authority under which the report with project is submitted is found in the United States and State laws, appended in chronological order.

Law of March 1, 1893, entitled, "An act to create the California Débris Commission and regulate hydraulic mining in the State of California," which, among other duties, requires the Commission to make examinations and surveys in the tributaries of the Sacramento River for the storage of mining and other débris; to make report of its work, with estimates of cost of such works as may be recommended; to consult with the State débris commissioner. It also directs that when appropriations are made the Commission build restraining works, etc., to prevent injury to the navigable waters, etc.

The river and harbor act of June 3, 1896, appropriates $250,000 for the construction of restraining barriers for the protection of the Sacramento and Feather rivers, such restraining barriers to be constructed under the direction of the Secretary of War, in accordance with recommendations of the California Débris Commission, pursuant to section 25 of the act of March 1, 1893; and also provides that the Treasurer of the United States is authorized to receive from the State of California, through the State débris commission, any and all sums of money that have been or may be hereafter appropriated by said State for the purposes therein set forth, and appropriates said sums when so received from the State to be expended in the manner therein provided.

The sundry civil act of July 1, 1898, modifies the act of June 3, 1896, and authorizes the Secretary of War in the preparation for and construction of said works to enter into an agreement that the contractor shall look solely to the State of California for one-half of any expense for construction of necessary impounding works, to be paid out of the State appropriation, the United States to be in no manner liable for said one-half.

The river and harbor act of March 3, 1899, provides that previous acts which permit contracts in which the contractor shall look solely to the State for one half of such expense, and that the United States is

not liable for that half, are hereby extended to any appropriations, when made, that may hereafter be made for such purpose. It also provides that the Secretary of War, in his discretion, in carrying out the provisions of any act of Congress providing for restraining barriers for impounding débris, when the aggregate of appropriations already made by State and Congress are available and sufficient to complete the same, may undertake the necessary work by hired labor and open-market purchases, and may accept payment as the work progresses, under and according to the acts of the legislature of said State for such purposes.

The following are the State laws above referred to:

Law of March 24, 1893, entitled, "An act to provide for the appointment, duties, and compensation of a débris commissioner, and to make an appropriation to be expended under his direction in the discharge of his duties as such commissioner."

Under said law the governor appointed a State débris commissioner. Two hundred and fifty thousand dollars was appropriated, to become available when the United States Government should appropriate a like amount, to be spent under the direction of the State débris commissioner for not more than one-half of the cost of construction of any such works for restraining and impounding débris, after approval by him and adoption and recommendation by the United States engineers (California Débris Commission) appointed for said purpose.

The State law of March 17, 1897, amends above act. It provides anew for the appointment of a State débris commissioner, makes it his duty to consult with the California Débris Commission in regard to plans for the construction of restraining or impounding works, and to submit such plans to the State board of examiners. The act also reappropriates the sum of $250,000, appropriated by the act of March 24, 1893, referred to above.

Since the organization of the California Débris Commission on June 8, 1893, it has given much thought and study to, and made many investigations of, the subject of impounding mining débris, to prevent further injury to the navigable waters of the State. The whole hydraulic mining field within the State of California under its jurisdiction has been inspected, and promising sites for impounding dams or barriers in the canyons and tributaries of these rivers have been examined by the Commission or its duly authorized agents.

After a careful review of all the information available, the Commission selected the Yuba River as the site of the first works to be constructed, since this river carries more detritus than all the other tributaries of the Sacramento River combined; and, accordingly, in September, 1897, very careful instrumental surveys, with borings, as a basis for a thorough investigation of the vicinity of the Narrows, where exists a natural site for impounding works, were begun by Assistant Engineer Hubert Vischer, civil engineer, under the direction of the Commission. This work, consisting of surveys, borings, shafts, tunnels, drifts, estimates, and designs for dams, with a diversion project for carrying the finer material to a settling basin 28 miles distant, occupied fully a year's time, and a detailed report showing what was accomplished in that time, with an estimate of cost of what is called the 1898 project, prepared by Mr. Vischer, is herewith.

Progress reports were made to the Commission nearly every week while this investigation was being made. The difficulty and expense of obtaining suitable foundation for so high a dam as that contemplated at the Narrows, the limited storage capacity of such a structure (about 35,000,000 cubic yards up to the level of the spillway), the uncertainty of being able to store the lighter débris and none of the immense quantity

lying in the river bed below the dam site, the excessive cost of the whole project (over a million dollars), which involves the boring of tunnels, building of flumes and canals, transportation of the finer materials by water through these works to a settling basin of very limited capacity, together with the fact that while these field investigations were progressing a far simpler and more comprehensive project was gradually being developed, made it incumbent on the Commission to consider the 1898 project with less favor, and to give attention to the new project, known as that of 1899, the details of which are also fully described in Mr. Vischer's report, and of which the following is a more general outline:

The latter project has for its primary object the storage of mining débris within the bed of the Yuba River by a system of works designed to separate the coarse material from the fine; and for a secondary object the controlling of the low-water channel within narrower and well-defined limits in order to preserve in place the extensive deposits in the river below; the general scheme being to erect several barriers across the bed of the river (shown on map A), the upper ones to be located about 3 miles east of the mouth of Dry Creek, known as barriers No. 1 and No. 2, respectively; another to be situated just below the mouth of Dry Creek, marked on the map as a flood overflow barrier; another to be placed at Daguerre Point, indicated as the Daguerre barrier; also to form a settling basin about 3 miles in length and one-half mile in width on the south side of the river; this settling basin to consist of a levee protected against wash, to be built in the bed of the river, with its upper and lower ends connecting with the existing levee and shore on the south bank; these end walls to have inlet and outlet weirs and conduits to regulate the inflow and outflow of river water, and to cause the finer material carried in suspension to be deposited and held in the settling basin, through which, at all except extreme flood stages, the river will be compelled to flow; and below this basin to confine the river channel within well-defined lines by necessary training works.

The upper barrier, No. 2, on map A, will have a height of about 40 feet above the present bed, and will extend entirely across the river. Its crest length will be 1,000 feet. This barrier is to consist of gravel, cobbles, brush, rock paving, and some masonry in its lower slope; a masonry crest, and a double row of sheet piling in its toe. It is to be built up gradually, the river flowing over it, and its chief function will be to impound coarse material behind it and form a new grade for the tailings, extending up to and beyond the Narrows.

Barrier No. 1 is to be located about one-half mile below No. 2. Its general construction is very similar to that proposed for No. 2. Its height will be 18 to 26 feet above the tailings now in the river, and the crest length proposed is 1,100 feet. At its northerly end will be a by-pass, with a weir 600 feet in length which will in extreme flood stages (assumed at 125,000 cubic feet per second) permit a flow over the lip of the weir 7 feet in depth, with a flow over the dam estimated at 3½ feet in depth. Cross sections of each of these proposed barriers are shown on sheet B.

Barrier No. 1 makes a water cushion for barrier No. 2. At all but flood stages of the river the flow will be through the by-pass or weir.

Both barriers together may raise the plane of river deposits about 40 feet, and are estimated to store, on an assumed gradient of 15 feet per mile, a volume representing 36,000,000 cubic yards of coarse material, at a cost of about seventh-tenths cent per cubic yard.

The next structure, a flood overflow barrier, is to be located about one-half mile below Dry Creek. It is to be a composite structure, consisting of some crib work, with rock filling and paving, and some sheet piling. It is a low structure, 4,000 feet in length, the cross-sections of

which are shown in figs. 3 and 4, on sheet C. During floods it will be submerged; at other stages of the river it will direct all the water into or through the settling basin.

The next barrier is to abut against Daguerre Point, extending south to the levee or embankment of the settling basin, shown on the general map, sheet A. Its crest length will be 3,000 feet and its general height 14 feet; its crest is not in a horizontal plane, being highest next the embankment alongside the settling basin and lowest at its northerly end, near Daguerre Point.

A cut is made through Daguerre Point to rectify the flow and to share with the northerly half of the barrier the duty of passing the flood waters. This barrier is to be essentially a brush and gravel structure, heavily protected with rock.

The flood-overflow barrier directs the ordinary flow of the river into the settling basin through inlets in the embankment forming the upper end of the basin. A profile of this barrier, with its openings and details of construction, is shown on sheet C. The volume of water entering the basin can be regulated by means of the inlet devices, and thereafter its discharge is similarly regulated by weirs and conduits at the lower end of the basin. Details of these works are shown on sheet C.

This basin, as designed, is capable of holding about 14,000,000 cubic yards of fine sediment, and by extending it farther to the westward it can be enlarged to a capacity of at least 50,000,000 cubic yards additional.

The project, as here outlined, is estimated to cost about $780,000, exclusive of the land required.

The project as submitted is novel, since nothing of the kind, so far as known, has ever been attempted, and it is to a certain extent experimental. The various structures are simple, and are believed to be safe, practicable, and reasonably permanent. They can be repaired if required, and if abandoned, not maintained, or never completed, can not leave the river in any worse shape than at present. If constructed, it is believed that they are capable of storing the débris now in the Yuba River and its tributaries, which is far in excess of that in all the other tributaries of the Sacramento River. The result of the storage can not be otherwise than beneficial to the navigation and commercial interests of the Sacramento and Feather Rivers. Especial attention is invited to the fact that the object sought to be accomplished is the storage of the detritus now in the Yuba and its tributaries, with a view to the improvement of the rivers below, and decidedly not with the view of permitting unlicensed or indiscriminate hydraulic mining at localities above the impounding works.

When the works have been completed and in operation for several years, there will be time and opportunity to determine whether or not the system is capable of sufficient expansion to warrant an attempt at storing therein the tailings from the hydraulic mines without compelling each mine to impound any or all of its débris.

The Commission believes the project practicable and worthy of adoption, and so recommends. It is the only one thus far evolved which gives reasonable hope of success, and at a very moderate cost for storage.

Mr. Vischer's labor, thought, and skill in working up a project of such unusual character and scope merits our highest appreciation and is worthy of every commendation.

Before construction work can be commenced, it is necessary to have, first, formal approval of the project by the Federal and State authorities; second, acquisition of title to the land embraced within the area occupied by the impounding works.

With reference to acquisition of land, the State law of March 17,

1897, authorizes from its appropriation of $250,000 the purchase or acquisition of so much land as may be necessary. A reading of the State laws applicable to the subject of impounding works makes it clear that the State contemplates sharing with the United States one-half of the total cost of the works. Congressional laws make it equally clear that the United States Government is to cooperate and act in harmony with the State, and also to share one-half of the total cost of the works. To accomplish this satisfactorily, it is believed that a legal interpretation of one or two points of law in the river and harbor acts of June 3, 1896, and March 3, 1899, may be necessary.

The act of June 3, 1896, appropriates $250,000 for the construction of restraining barriers, etc. This act neither authorizes nor prohibits the expenditure of any portion of this appropriation for acquiring land necessary for impounding débris. It is therefore important to know whether or not any portion of the $250,000 appropriated by Congress can be used to pay for one-half of the cost of acquiring the necessary land for the impounding works. The aggregate amount of land required within the area embraced in the existing project is 2,000 acres, for which about $20,000 is believed to be a fair and reasonable compensation.

The river and harbor act of March 3, 1899, leaves it discretionary with the Secretary of War to do the work required by hired labor and purchases in open market when the aggregate of appropriations made by Congress and by the State are available and sufficient to complete the work. The aggregate of above appropriations available is $500,000. The estimated cost of the whole project, including purchase of land, is $800,000. Under these circumstances it is desirable to know whether or not commencement of the work must be delayed until $800,000 shall have been appropriated or if we can commence work and continue the same to the extent of the $500,000 now available.

The Commission recommends, for the best interests of the service, that some of the work be done by contract and that other portions be done by hired labor and purchases in open market.

Respectfully submitted.

S. M. MANSFIELD,
Colonel, Corps of Engineers.
W. H. HEUER,
Major, Corps of Engineers.
HERBERT DEAKYNE,
First Lieut., Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

REPORT OF MR. HUBERT VISCHER, ASSISTANT ENGINEER.

SAN FRANCISCO, CAL., *January 15, 1900.*

GENTLEMEN: I have the honor to submit the following report relating to storage of mining detritus in Yuba River, California:

The reports of earlier investigations upon the same subject are to be found in House Ex. Docs. No. 69, Forty-sixth Congress, second session; No. 76, Forty-sixth Congress, third session; No. 98, Forty-seventh Congress, first session, and in No. 267, Fifty-first Congress, second session.

These investigations have considered the subject with reference to proposed dams at Daguerre Point and at the so-called "Narrows" of the Yuba River, a precipitous gorge located about 1½ miles northeast of the village of Smartville, Yuba County. At this point a high rock dam was proposed. Below the Narrows the river passes into the foothills bordering the Sacramento Valley, and the alternative project was a low rock dam at Daguerre Point, about 6,000 feet in length, connecting two rocky promontories which abut upon the river, thus inclosing an extensive area of destroyed lands. Not far below this point the levee systems upon both sides of the Yuba River begin, and extend to its mouth at Marysville, about 10 miles below Daguerre Point, the distance of the latter from the Narrows, by river, being also about 10 miles.

During 1880 a brush dam was constructed by the State of California about 1¼ miles below Daguerre Point, but the same was soon afterwards breached in several places and was not afterwards repaired. The most extensive surveys of the Yuba River were made by the State just prior to that year, and the records are to be found in the reports of the State engineer.

The character of the material sought to be retained behind these dams was not very clearly defined, except presumably about such as was then deposited above the sites. In September, 1897, the writer received instructions to make surveys at the Narrows and to prepare estimates for a dam, the impervious character of which would furnish a water basin presumably capable of effecting the deposit of all material liable to cause obstructions and affect navigation in the flat reaches near the mouth of the Sacramento River. This condition is important, both as to cost of works and storage capacity, and deserves consideration in comparing present with former estimates.

In the course of the investigations it became apparent that physical obstacles as well as cost placed a limit to the height of the dam, lower than that formerly contemplated, and that as regards fine material the storage capacity was disproportionately small, leading directly to the conclusion that fine sediment storage behind dams in narrow gorges is not economical. Upon this conclusion efforts followed to discover a means to separate out the finer elements, such as might be capable of transportation in long canals or flumes, and to conduct these and settle them out upon flat lands entirely beyond danger of subsequent removal. The point in question is of great importance, for mining detritus consists of all grades of material, from bowlders or large cobbles to the finest silts and slimes, and all these follow different laws as regards their transportation by water, each grade being in turn the most or the least objectionable obstacle in proportion to the steepness of the gradient or the velocity of the current in connection with which it is considered. The coarse elements by themselves are capable of secure and also cheap lodgment, and storage areas are abundant, whereas the finer material can hardly be considered permanent y secure until lodged entirely beyond the reach of strong currents. The finer material is capable of forming the most fertile soils and may be readily conducted long distances in artificial conduits, differing again from the gravels and coarser sands, which by themselves create only havoc and ruin when deposited on arable lands.

Surveys in connection with the Narrows Dam showed the possibility of such treatment, but only by the aid of mechanical methods to bring about classification and a class of works costly beyond the limit of the fund available. Other objections presented themselves by the extreme exposure to which the proposed dam would be subjected, its great cost in comparison to the results, the obstacles to its construction, and, more than all, that it would leave entirely unprovided for those immense accumulations of detritus now temporarily deposited between the Narrows and the entrance to Feather River, and which are year by year being carried into that stream.

The investigations, which have been hurriedly outlined and which will be more particularly described hereafter, were not completed until the month of December, 1898. A system of surveys was then commenced, which extended to the mouth of the Yuba River and which carefully noted the conditions as they now exist. The object of these studies was to apply the experience gained at the Narrows, to seek to accomplish the segregation of material under less difficult circumstances, to deposit the finer elements by means of shorter, less costly conduits, and to confine the flow of the river to well-defined and permanent channels, for if channel building is practicable throughout the lower 10-mile reach of the river, the large bodies of sand and sediment over or through which the river now flows at random will be for the most part isolated, and as the lands produce timber good soils will form and permanent reclamation will be accomplished.

With further accessions of detritus prevented and the flow of the Yuba adequately controlled, a rational basis would then be established for the improvement of the navigable rivers.

This report divides itself, therefore, into two parts—the earlier investigations made principally during 1898 and hinging upon the Narrows and the later studies lower down the river, the "project of 1899."

THE "NARROWS" PROJECTS.

The work connected with the Narrows covers the period from September, 1897, to December, 1898. During this period almost the whole time of the writer, aided by an assistant, was devoted to this work, in prosecution of which, besides frequent surveys, mostly of a reconnoissance character, a considerable force of laborers was at times employed. The services of this force were required in making test borings to determine the depths of the gravel deposits in the river bed and afterwards in prospecting work aiming to determine, by means of shafts and trenches, the character and position of rock formation at points supposed to be desirable to build upon. Prior to this work a supply of water was brought to the Narrows by a flume, ditch, and pipe line, about 1½ miles long, it having become manifest quite early in the investigation that the development work would be of an unusually extensive and difficult character and that a considerable supply of power would be required.

Steam power was not advisable, nor was ponderous machinery permissible for several reasons, so that water power and make-shift apparatus, portable enough to be readily removed in case of freshets, appeared essential. Events repeatedly proved the judiciousness of this assumption.

The work was entirely tentative in character, which was partly due to physical conditions, but also by reason of the broad scope of the investigation. High dams had been considered and, practically speaking, recommended in former reports, and such structures appeared essential to provide the large quantities of storage sought for. The object was, broadly speaking, to establish facts, not necessarily limited by funds now available, so that at the outset a dam 150 feet high, or even 200 feet, did not appear at all unreasonable, and preparations were made to show the conditions even for such a height. As a first step in the work an accurate contour map of the canyon was prepared, platted on large scale, with very close contour intervals. It is based upon nearly 2,000 rod determinations and side notes, the contours being sketched in on the ground from platted points upon detail sheets of 20 feet to 1 inch scale. This map was necessary, owing to there being three locations at which dams appeared feasible, and it was apparent that various projects might be brought into close competition. Attention is invited to this map, a copy of which, and a partial duplicate of the same, accompany this report (sheet No. 1 and sheet No. 2). Upon the latter is shown in plan the dam upon which a final estimate was based, the former showing the location of the three proposed dam sites. Upon it will also be seen the location of the various test borings, shafts, trenches, tunnels, and surface exposures which were made in the course of this work, and which are further illustrated by well-annotated sectional drawings and by the tabulated records which follow. As dates also are given in the tables, the logic and progress of the developments may be followed without an extended description at this time, especially as separate progress reports of the work have been submitted from time to time and are on record.

Record of well borings in bed of Yuba River at the Narrows.

MIDDLE DAM SITE.

Hole number.	Elevation on bottom (bed rock).	Depth of hole in gravel.	Commenced.	Finished.	Number of working days.*a*
	Feet.	*Feet.*			
1	242.1	53.5	Mar. 31	Apr. 5*b*	4
2	246.1	50.1	Apr. 8	Apr. 13*c*	4
3	241.4	55.0	Apr. 19	Apr. 21	2
4	236.7	60.0	Apr. 22	Apr. 25	3
5	239.3	56.9	Apr. 26	Apr. 29*d*	2¾
6	253.6	42.0	May 3	May 4	1½
7	273.6	24.0	May 4	May 5	1
8′	270.0	26.0*e*	May 5	May 6	1
8	269.8	26.0	May 6	May 7*f*	1

UPPER DAM SITE.

9	261.9	37.0	May 9	May 10	1
10	248.4	49.0	May 10	May 11	1½
11*g*	225.7	71.3	May 12	May 18	5¼
12	255.1	37.5	May 19	May 20	2
13	246.4	49.5	May 21	May 23	2
14	232.6	64.5	May 25	May 28	3¼
15	237.9	59.5	May 30	June 1*h*	3
16*i*	234.2	55.5	June 8	June 8	... .

a Including pulling of pipe and moving derrick frame to following hole.
b March 28 to 30, 1898, three holes started and given up. April 6 and 7 spent upon two unsuccessful holes.
c April 13 to 19 consumed upon two unsuccessful holes and in experimenting.
d April 30 pipe was extracted from a hole 38½ feet deep on account of the shoe having become detached. Pressure gate blew off and repairs to pipe line were not finished until May 2.
e At 26 feet depth, in shooting hole, the foot piece was blown off, but the depth afterwards agreeing with No. 8, the hole was accepted as a bed-rock determination.
f May 7, line of pipe extended to upper site and machine moved to it.
g This hole caused much trouble on account of coarse bowlders.
h June 1 to 8, no work, river being too high to attempt No. 16, which is in channel way at the middle site.
i This hole was sunk in swift current 6¼ feet deep; depth in gravel, 55¼ feet; sunk in 7 working hours.

Record of well borings in bed of Yuba River at the Narrows—Continued.

LOWER DAM SITE.

Hole number.	Elevation on bottom (bed rock).	Depth of hole in gravel.	Commenced.	Finished.	Number of working days.*a*
	Feet.	*Feet.*			
17*b*	208.75	81.0	June 23	Aug. 8	16
18*c*	205.5	84.3	Aug. 9	Aug. 20	9
19*d*	202.5	84.9	Aug. 22	Aug. 30	8
20*e*	206.1	82.75	Aug. 31	Sept. 5	5
21*f*	223.6	73.0	Sept. 6	Sept. 16	7

a Including pulling of pipe and moving derrick frame to following hole.

b Work begun June 23 and hole sunk 40 feet by June 26, when operations were ordered suspended. Work was not resumed until July 25. On August 8 lower section of 11½ feet of pipe twisted off, the bottom of hole then being at a depth of 81 feet, and probably on bed rock, or very close to it. The material consisted of cobbles, bowlders, and coarse wash, containing little fine material the removal of which would make room for the descending pipe.

c Through cobbles and gravel; progress almost uniform at rate of 9 feet per day.

d Cobbles and gravel; practically uniform advance.

e Gravel and sand.

f Hole located 60 feet from rock face on west bank. Material similar to that in No. 17. In drawing outer pipe it became so tightly bound in hole that it could not be extracted. Fifty-six and one-half feet of 3-inch pipe and two shoes left standing in the hole.

Record of development work to test formation of abutments in connection with Narrows Dam.

LOWER GROUP OF HOLES.

Shaft.	Elevation.		Depth.	Remarks.
	At surface.	At bottom.		
	Feet.	*Feet.*	*Feet.*	
A	308.0	296.0	12.0	Through seamy rock, striking water at bottom of shaft
B	342.6	319.6	23.0	Soil, 4 feet; alkali sand, 16 feet; decomposed rock, 2 feet; in solid formation, 1 foot.
C	356.5	349.5	7.0	Soil and alkali sand, 6 feet; decomposed rock, 1 foot, reaching good hard blue rock at bottom.
D	371.5	331.2	40.3	Soil, 4 feet; alkali sand, 18 feet. Total depth as a shaft, 22 feet, extended with churn drill 18.3 feet, reaching hard formation, possibly bed rock, at bottom of drill hole.
E	389.0	344.0	45.0	Through soil and clay, 6 feet; through decomposed rock, 39 feet, gradully passing into harder layers of same formation (volcanic rock changing into clays) at bottom. Five sets of timbers required to hold sides.
G	362.6	336.1	26.5	Through clay and shaly rock, 11 feet; hard seamy rock, 11 feet; gradually hardening, 4.5 feet. Stopped in what may be called "country formation," but still decomposed material.
X*a*	341.5	334.5	7.0	Opened for 25 feet in length, parallel with channel, of which 17 feet developed hard blue rock at 7 feet.
UPPER GROUP OF HOLES.				
(a)	376.5	356.5	20.0	As a shaft, 6 feet in red soil, then extended with churn drill 12 feet; resumed as a shaft and carried down to 20 feet; abandoned at 20 feet, no formation being struck; required timbering from 6 feet down.
(b)	392.9	375.9	17.0	As a shaft, 9 feet; extended with drills, 8 feet; struck hard material, probably a bowlder.
(c)	409.5	388.0	21.5	As a shaft, 4½ feet in rocky soil; then with drill, 17 feet, getting spoon samples of blue-rock drillings, but probably only a bowlder
(e)	433.6	416.6	17.0	An open shaft for 11 feet; then three holes were sunk with drill, striking bowlders each time.
(f)	345.1	337.1	8.0	Sunk 8 feet in clay and bowlders, then abandoned as being too low down in basin and not likely to develop any reef which might exist.

a Cross trench.

EXPLANATORY STATEMENT.—Work was done on shafts A to D from March 10 to 24, 1898; was then suspended, but was resumed and the tests on these shafts completed May 10 to 12. Work was done on shafts a, b, c, e, and f between May 12 and May 26. Shafts E and G and the cross trench X were worked upon from May 23 to June 17. Operations on open trenches No. 1 and No. 2 and in the lower part of No. 3 began May 30 and continued until June 29, when all work was ordered suspended. Work was commenced on trenches No. 3 and No. 4 July 25 and concluded August 30, the drift or tunnel running off from trench No. 3 being started August 15 and finished September 5. Trench No. 5 was excavated between September 1 and 17. During all this period there was a force of about six men kept steadily engaged, with an occasional increase to 12 or 14 men. Work with the stump-pulling machine on west side of canyon began August 13 and finished August 30, the force being a foreman and 5 men, with 1 horse and a driver.

The test borings in the river bed were made with an apparatus contrived for the occasion after an attempt had shown that open shafts could not be used owing to the large pumping appliances that would have to be provided, no well-boring device being known applicable to the work nor any contractor found desirous of undertaking it. After some time had been consumed in studying details and supplying deficient parts the outcome was a combination of a few properly adapted pipes operated partly by suction and partly by pressure, which proved themselves capable of penetrating the most perverse ground, as the device permitted drills being used, and charges of dynamite in tin cartridges exploded under the shoe, whenever an unusually large bowlder was met or the presence of bed rock had to be demonstrated. The rate of advance varied with the coarseness of the the deposits, but progress was certain in every case and holes were successfully put down under several feet of swift-flowing water. The gravels consist of everything from large cobbles and bowlders down to fine sands, generally granular, but silts and slimes are entirely lacking, owing to the swiftness of the current. The depth of deposit varies from 50 to 85 feet, according to locality, the lower line of holes showing the latter depth. The cross sections determined by the three lines of borings are shown platted from a common datum line for readier comparison of the depths at the three dam sites.

The Narrows Canyon is a contracted gorge about 3,000 feet long, the width across channel at the present bed varying between 160 feet and 260 feet. The walls rise precipitously for 200 or 300 feet above the plane of the gravel deposits and then ascend rapidly to an altitude of 1,000 feet or more, with a distance of about a mile between the ridges. At three points rocky bluffs or promontories wall in the river, rising with sometimes overhanging slopes, the one on the left bank near the lower end of the canyon for nearly 300 feet and the two on the right bank near the upper end for about 180 feet from the water level. These precipices are faced by flatter slopes upon the opposite side of the river, generally broken into benches of rock with an occasional soil covering. The two other prominent topographic features, and both shown clearly on the map, are the large "slide" on the right bank, and opposite to it the remarkable cleft, or inclined chasm, which interrupts the wall upon the south side. Both of these mark breaks in the formation and are especially important as dividing the canyon for building purposes into an upper and a lower half. As the slide is not a suitable bearing to abut work upon any dam to be constructed in this canyon must be either entirely above or entirely below the slide.

The estimates made in a previous report appear to have been based upon the lower site, and it is the one which has always attracted popular notice, but comparative estimates based upon several types of dams proved that up to a height of 200 feet there was a difference of about 15 per cent in quantities against a dam at this site and in favor of a location at one of the upper sites, for which reason attention was more particularly directed to the upper portions of the canyon. The constructive difficulties due to the greater depth to a rock foundation at the lower site, as subsequently shown, had a bearing in the same direction.

The upper one of the three dam sites was at first especially favored, owing to the excellent opportunities for a waste way on the right bank. But the system of shafts on the left bank utterly failed to show suitable conditions on this side, and the site had to be condemned. The search for bed rock was a careful one, and it will be seen that the shafts are arranged in two groups, the one set aiming to disclose an abutment at the extreme upstream limit, and the other to do the same at the extreme downstream point, which might serve for a left-bank abutment for a dam whose opposite end would rest upon the uppermost rock promontory. Between these two locations the ground formed a basin and no result was to be expected.

Prospect work was extended down the left bank of the canyon, covering ground between the middle site and the deep chasm already noticed, but deep open trenches, sluiced out with water, and tunnels or shafts from these were substituted as a more effective and also a more economical mode of demonstration. The work failed to show satisfactory ledge rock above a certain plane. Near the chasm the rock crops out about elevation 500 feet, but drops off as one proceeds upstream and approaches the river. At the middle dam site the bed rock forms only a narrow ridge facing the river, the highest point of which is but little above elevation 400 feet. Above the rock lines thus described the formation is of secondary character, fragmentary country rock, mixed with an indurated earth or shale of a character to stand up well when dressed to steep slopes, but not capable of withstanding violent action by running water unless well protected with masonry.

It may be concluded, as far as the left bank is concerned, that a storage dam is practicable to a height of about 100 feet above the level of the river bed, but for a higher dam the site would not be advisable.

Upon the right bank a sufficient demonstration of practicability was made by the partial stripping off of an area which is designated upon the map. The surface of this area was strewn deep with blocks, some of them weighing many tons, apparently from the rock promontory close by. The stripping was made with a stump-pulling machine, modified to grapple rocks, and answered the purpose admirably.

A sloping ledge was uncovered, somewhat rifted and fissured, but evidently in its original position, or practically so, and undoubtedly capable of being made a secure abutment for masonry, after its fissures had been built in with concrete and the open seams properly grouted. There was no opportunity for prospecting the slide, but the latter appears to consist of an aggregation of immense bowlders (up to 10,000 tons in weight), with a talus of rock and earth extending down to the river. It evidently contains some of the best building rock to be found in this locality, and the simplest disposition to make of it would be to make it a quarry, and to reduce its top load by working it into the dam.

Rock for building purposes is found in quantity. Quarries may be opened almost anywhere. The rock is hard, but friable, showing characteristic planes of cleavage, with angles of about 30 and 60 degrees, and there is a suggestive similarity between the strikes, dips, and faces of the benches and slopes which make up the canyon and the form of individual weathered bowlders, the same shapes appearing even in small fragments of the rock after it is broken up. This regularity of rock structure is a valuable feature well calculated to produce uniform, compact rockwork. Throughout the canyon there appears to be an upper and a lower zone of rock, the same rock, but differing in density and the extent of fissuring, due, apparently, to different conditions of cooling and pressure. There are good facilities for generating power, and excellent opportunities for stretching cables to transport material. The clean-washed mixture of gravels and square-cornered sand, which constitutes the river deposit at this point, only requires the addition of cement to make admirable concrete.

The dam.—The type of dam suggested for the location selected (the middle site) differs from other dams, but is designed for the unusual requirements of its service, aiming to make an economical use of the material at hand, and also to fit nicely upon the limited areas of good abutment shown to exist by the prospecting work. It consists of a foundation, which is carried down through the river deposits to bed rock, and, above the level of the present river bed, of three benches or steps of rock masonry, heavily protected upon its outer slope by having its rock laid in cement concrete. Each bench represents a stage in construction, and is intended to be added to as requirements for storage increase. The dam would at first be about 40 feet high above present river level at low-water stage, then 70, and finally 100 feet, with an additional 5 feet added at either end, these heights corresponding to elevations 330, 360, 390, and 395 feet, in our system of levels, which are based on mean low tide in Sacramento River, at New York Landing, being practically tide level, the same datum that was used in the surveys of the State engineer.

A dam thus built up in stages, except during high water, would accumulate behind it principally fine sediment and slimes, that is "slickens," and experience with impounding dams has shown that this is not a safe material to build rockwork upon. For this reason it was proposed to support each addition to the dam upon the sound, clean material now found in the channel, the plan being to give the first or lower bench at the outset the full width called for by the completed structure, taking care to provide material to build the upper additions by utilizing the space marked "storage for reserve gravel" on sheet No. 2. Its accessibility whenever wanted was insured by providing a drainage tunnel past the dam at the low level indicated on the drawings, but a large part of the gravel would be obtained from below the dam. This plan would call for handling a total quantity of 300,000 cubic yards of gravel to supply 158,864 cubic yards actually needed in the dam, but the gravel would be moved and deposited by hydraulic elevators and through flumes, and the cost for actual moving is by this system very small. All requirements for power on the work have been estimated on a hydraulic basis. The "gravel reserve" storage capacity between levels 290 and 330 feet amounts to 138,527 cubic yards, and the drainage tunnel was estimated to carry about 1,800 cubic feet per second, which is more than the average winter low-water flow (assumed to be 1,500 cubic feet), but not sufficient to carry the flow during freshets, at which time elevating operations in the gravel reserve might have to be discontinued.

It will be seen by consulting the drawings that the main body of the dam was to be gravel and cobbles, but the masonry revetment on the lower face was so substantial in character as to almost justify considering it a reclining masonry dam, supported upon rock and gravel. A great volume of water would pass the structure, at times possibly 125,000 cubic feet per second, and care was taken to give all possible relief by means of a large waste way, and a discharge way in the dam, with offset walls at the sides, directing the current centrally away from the abutments and in good alignment with the canyon below. The dam was also protected by an auxiliary rock barrier 500 feet below, which would insure a deep water pool in which the descending torrent might waste its energy. It remains to be explained that the "dry rubble" rockwork behind the masonry facing was to have gravel and sand sluiced into the interstices, making it and the immense gravel backing above it practically impervious and as free from the effects of settlement as it is possible to make a new structure. Some settlement would be unavoidable, and small quantities of

water, percolating through the upper masses, might collect behind the masonry and create hydrostatic pressure, taxing the facing as severely as if no backing existed between it and the reservoir. This effect it was proposed to offset by liberally perforating the masonry skin, so as to prevent accumulation; and, if so desired, to construct the face not as a monolith, but in large sections, suitably divided vertically and horizontally, so that the skin might be free to settle conformably with the backing, and strains from varying temperature be also compensated. These precautions should overcome the objections ordinarily raised against composite dams. The upstream face was also protected by cement work and laid-up riprap, to guard against destruction from above the dam by an undermining of this slope in case gravels were to be carried over the crest, which is not an impossible contingency.

The most difficult part of the undertaking and the most costly is the foundation. This your Commission decided must be carried down and connected to bed rock underneath the dam. It is essential that this should be so, otherwise there would be no guarantee that the torrents which would pour over the dam might not undermine it. The importance of the work and the largeness of the interests involved demand that the utmost precautions be taken, for the dam contemplates doing what no dam has undertaken to do, which may be realized by considering that there may be times when the passing floods would produce a power represented by 3,900 tons falling 100 feet each second, and the theoretical velocity at the toe of the dam being about 80 feet per second, or 55 miles per hour. It is also essential that the work be so arranged that during construction storms or high water may only involve temporary suspension without risking loss of work partially completed.

The plan of operations would be the following: As a preliminary step it would appear advisable to lower the water in the river below level 284 feet by deepening a part of the channel, using a gravel elevator for this work. It would then be in order to construct a masonry wall across the channel and down to bed-rock bottom. This would be done by means of a series of masonry caissons, each about 30 feet long, put down by pneumatic methods, and afterwards jointed to form one wall by filling the recesses left for that purpose at the ends of the caissons. The details are indicated upon a separate sheet (see sheet No. 4). The subsurface flow would be shut off by this wall, and a surface flow of 5,780 cubic feet per second (23,120 miners' inches) might then be conducted in an open wooden flume and discharged in o the river 700 feet below its head. Details of the flume are also given on sheet No. 4, the reason for constructing which entirely out of planking being to provide for reuse of the lumber in other parts of the work, and to facilitate shifting the flume to the opposite side of the canyon at a later period of the work.

After constructing a small portion of the lower part of the "rock barrier" in order to shut off backwater, a timbered trench would be opened up across the channel at this point for the purpose of building a thin concrete wall, 18 inches thick. The purpose of this wall being imperviousness, not strength, it would be backed up by gravel tamped in behind it, and the detail drawings on sheet No. 4 show that a large or a small portion of the trench may be kept open as the exigencies of the work may determine. The trench is, in fact, an elongated mine shaft, with extensible ends, the timbering being similar. The depths along the bottom of the trench would be regulated to suit convenience, and a sump maintained away from the point of sinking, the gravel and seepage water being raised by an ejector. The timbers would not be drawn but left standing to support the wall, which, after the trench was back-filled, would become a blind wall and serve to shut off underflow at the guard barrier.

It will be apparent how this wall and the caisson wall would inclose a section of the river deposit between them, and the water pass over them. Operations could be conducted within the compartment formed without trouble from outside water, and the large body of gravel designated "preliminary excavation" on sheet 2, could be removed and deposited in the dam. The lines of this excavation are so arranged as not to rob the cross walls or the "slide" of their support.

There would still remain beneath this excavation the gravel filling the space to be cleared for the foundations. In order to excavate this gravel safely a system of mining in supported trenches was proposed in the manner indicated by the drawings shown on sheet 3. The work resembles that proposed for building the blind wall, except that the openings would be wider and all timbers are intended to be taken out and reused. A beginning would be made along the left river bank, where a part of the surface of the excavation would be within 30 feet of the original river bed, a depth not too great to reach with an ordinary timbered trench. A trench would be opened at this point, making the natural rock wall of the canyon one side and bracing the other from it. When a suitable length of bed rock had been exposed, the portion of the "foundation apron" necessary at this point would at once be built, with its proper allowance of concrete facing. The trench would, at the same time, be advanced upstream another section, the finished work replacing the cross braces, but the side sheathing for the present remaining. This process would continue

until the main wall was reached, the sides of the trench, however, becoming deeper with each advance, but so small a section of the caisson wall would be uncovered that props from the newly-laid work would sustain the downstream thrust coming from above the wall. The drawings show the manner of timbering, full lines indicating timbers already set and broken lines the timbers next to follow. This first section of the apron being finished, the second section would be begun, in doing which the lagging and side-supporting timbers of the first section would be recovered. In practice it would not be necessary to complete the first section before starting the second, and the work in one would closely follow the other. Cross trenches could be opened, but the work should always progress toward the points where a withdrawal of support might occasion most trouble. The drainage flume would, after a time, be shifted to the left side of the stream and supported on finished work.

The worst setback which could occur would be a flooding of the work pit, if the flume were unable to carry the flood, or became badly damaged. But this would only cause temporary delay, for the contemplated capacity of the elevating apparatus would be equal to pumping out the working pit, even if it were completely opened, in about sixty hours' consecutive work.

As regards the time to be allowed for construction, it is estimated that a single caisson of maximum depth might be put down in thirty days, and that with two such kept sinking at a time, the six caissons necessary to form the cross wall could be put down and joined together in from seventy to ninety days. This would probably consume the whole of one season of moderate flow, seven or eight months in ordinary years, to complete the foundation work. During this time work on the main body of the dam would be going forward, and it is probable that in about one calendar year, if the work were properly outfitted with plant, so much of the superstructure could be completed, perhaps the lower bench, as might appear expedient for a beginning, the demand for storage alone being considered. So far as strength goes, the dam might be completed to full height without intermission, for it is abundantly massive to impound water as well as solid detritus. Besides, it would be much less exposed after the wasteway became operative than at a lesser height, when almost all the flow would have to pass over the crest.

The estimate of cost in detail is so voluminous that it is deemed preferable to here give only epitomized figures. Entries which give quantities and total amounts, but no specified rates, are to be understood as summaries.

Estimate for a dam at the Narrows.

[Crest elevation, 390 feet; wings, 395 feet; nominal height, 100 feet.]

1. Masonry caisson wall, complete:		
180 linear feet, at $261.67		$47,100.60
River bottom assumed to be level. Elevation of bed, 220 feet.		
Cost of one caisson, 29.5 feet long, being as follows:		
Ironwork	$3,574.50	
Framework and lumber	475.70	
Masonry and concrete	2,339.00	
Steering pipes and fixtures	250.00	
Power and labor for placing	1,080.00	
	7,719.20	
(Cost per cubic yard of masonry, laid, $19.40.)		
2. Trench and concrete wall at rock barrier:		
Timbering	4,199.50	
Excavation, 11,000 cubic yards, at 35 cents	3,850.00	
Concrete, 1,297 cubic yards, at $7.50	9,727.50	
		17,777.00
3. Rock barrier:		
Dry rubble, 17,050 cubic yards, at $1.15	19,607.50	
Brush mattress, 1,037 cubic yards, at $2.20	2,281.40	
		21,888.90
4. Drainage flume (capacity, 5,780 second-feet)		3,350.00
(Partial allowance for reuse of lumber.)		
5. Excavation of foundation pit:		
Labor and timbering, 56,482 cubic yards, at 25 cents		14,120.50
(Cost of elevating gravel being included in No. 10.)		
6. Foundation apron:		
Dry rubble masonry, 46,875 cubic yards, at $1.15	53,906.25	
Concrete protection of outer face, 3,453½ cubic yards	20,720.00	
		74,626.25

7. Drainage tunnels and shaft:		
Including approaches and exit, portal walls, masonry head works, and regulating timbers—		
Lower tunnel	$19,278.11	
Upper tunnel	3,832.94	
Shaft	2,204.87	
		$25,315.92
8. Dry rubble in dam (above elevation 290 feet):		
Lower bench, at $1 per yard	26,626.00	
Middle bench, at $1 per yard	34,500.00	
Upper bench and end wings, at $1 per yard	55,128.50	
		116,254.50
9. Masonry protection of face (above elevation 290 feet):		
11,560 cubic yards		69,360.00
10. Gravel body of dam:		
Including cost of reservoirs, flumes, ditch, and pressure pipe; also charge for water and cost of elevators and delivery flumes		25,550.00
Estimated quantity of gravel requiring to be handled once, 300,000 cubic yards, at an average cost of 8½ cents, representing an amount of 158,864 yards contained within the lines of the dam, the balance being wasted or allowed for twice on account of excessive height of lift or necessity for temporary storage and rehandling.		
11. Concrete protection of crest and upper face:		
Crest	$1,636.50	
Upstream face	7,506.60	
		9,143.10
12. Riprap paving on upper face of dam:		
6,340 cubic yards, at $1.25		7,925.00
13. Masonry wall on west side of waste way (length, 119 feet):		
354 cubic yards of concrete, at $8		2,832.00
14. Training wall on spur (west side of waste way):		
97.17 cubic yards masonry and concrete, at $8		777.36
15. Excavating waste way, allowance being made for use of a portion of rock in dam:		
Apron, below level 370 feet, 24,957 cubic yards, at 50 cents	$12,478.50	
Between levels 370 and 410 feet, 105,119 yards, at 40 cents	42,047.60	
Above level 410 feet, 60,636 yards, at 35 cents	21,222.60	
		75,748.70
16. Concrete paving in waste way (also bottom and side of waste chute):		
Filling seams and protecting soft rock, 476 cubic yards of concrete.		3,620.00
Total estimate		515,389.83

In comparing these amounts with the estimates accompanying previous reports it should be considered that the latter cover only rockwork in the dam, or, rather, barrier system, and make no mention of any foundation or waste way nor of devices for controlling the flow of the river during construction or afterwards. The tables on page 88 of the 1882 report, House Ex. Doc. No. 98, for a height of 100 feet give the following:

Lower barrier of 75 feet	204,345 cubic yards, at $1	$204,345.00
25 feet addition to 100 feet	59,496 cubic yards, at $1.25	74,370.00
		278,715.00
Contingencies, 10 per cent added		27,871.00
Total		306,586.00

And an unprinted estimate based upon similar dimensions, which was prepared in 1890 to accompany the report published in House Ex. Doc. No. 267, gives the following figures:

Barrier, 75 feet	205,000 cubic yards.	
25 feet addition to 100 feet	70,500 cubic yards.	
	275,500 cubic yards, at $1.30	$358,150.00
Contingencies, 10 per cent added		35,815.00
Total		393,965.00

If we segregate from the present estimate items 8, 9. 10, 11, and 12, which represent all the quantities contained in the dam above level 290 feet, we have the following:

158, 864	cubic yards gravel backing	$25, 550. 00
116, 254. 5	cubic yards rockwork at $1	116, 254. 50
	Cost of masonry slope protection above 290-foot level	69, 360. 00
	Cost of masonry protection of crest and upper face	9, 143. 10
6, 340	cubic yards riprap on upper face, at $1.25	7, 925. 00
281, 458. 5	cubic yards for	28, 232. 60

showing the present amounts to be the lesser ones.

The present design shortens the distance from crest to outer toe of dam one-half, yet increases the total length of base by addition to the upstream side, and if it be conceded that a cement masonry protection of the lower face be necessary it is practically immaterial whether the inclination be 1 on 2, as now proposed, or 1 on 4, as was proposed in the plans of former years.

As regards other types of dam, a high masonry dam as customary for water storage, was not applicable, for at the middle site the abutments are not suitable for such a dam. At the lower site the abutments might be suitable, but, besides other complications, the deep foundation would cause difficulty, and at either site the cost would be prohibitory. A dam of the random-stone order has been the popular conception, the intention being to mine and gallery the cliffs and to blow down immense masses of rock, which would in course of time find their own foundation. Though attractive, it is questionable whether the economies claimed for the system would be realized. It is, moreover, defective in principle; for, as the dam grew higher, so would the undermining action from floods increase, and there could be no assurance that things had ever reached their final order.

Storage.—In the month of September, 1898, a survey of the river above the Narrows was made with reference to storage determinations. Cross sections of the canyon were taken at intervals of about 500 feet, with additional observations where the topography required it, the work being carried up 2¼ miles above the entrance of the South Fork, and up the latter to Bridgeport. Calculations were made of the storage prisms contained below planes beginning at several levels at the dam and inclining upstream upon gradients of 15 feet per mile, 5 feet per mile, and horizontal. The results are recorded in the following table, entries marked with an asterisk being approximations derived from the other amounts:

Storage of Narrows Dam at different levels and on various slopes of deposit.

[NOTE.—The distance from the dam to the mouth of South Fork is 8 miles.]

Height of dam.		Assumed storage gradient (feet per mile).	Distance from dam to head of basin.	Storage Capacity.
When filled to a depth of—	Or to elevation—			
Feet.	*Feet.*		*Miles.*	*Cubic yards.*
40	330	*a* 5	2. 52	3, 272, 400
40	330	*a* 15	5. 61	8, 933, 000
60	350	5	4. 12	7, 707, 000
60	350	*a* 15	8. 20	19, 174, 000
80	370	(*b*)	4. 12	11, 604, 000
80	370	5	5. 52	16, 170, 000
80	370	15	9. 75	34, 965, 000
100	390	5	5. 85	27, 212, 000
100	390	15	*c*{10. 22 0. 70}	54, 767, 000

a Approximate, being derived from other amounts. *b* Horizontal.

c For 10.22 miles up Main Yuba; 0.70 up South Yuba.

Cost per cubic yard of material stored.

By present estimate, assuming dam to cost $500,000, on slope of 15 feet per mile:

At a height of 80 feet, 1.43 cents per yard; at a height of 100 feet, 0.91 cents per yard

Or, for modified dam, estimated to cost $570,000, at height of 100 feet, 1.04 cents per yard.

The storage table, page 88, House Ex. Doc. No. 98, gives by former estimate:

Estimated capacity at 100 feet, 50,272,003 yards; estimated cost of dam $306,586; cost per cubic yard of storage, 0.61 cent.

The grade of 5 feet per mile was assumed to represent storage for fine material, and 15 feet for coarse material, the former because it approximates the minimum grade near Marysville where the deposit is fine, and the latter because it is somewhat less than the least grade above the Narrows. Such estimates are approximations, for besides the gradient being assumed, it is not accurate to assume that the surface of the deposit would be a plane. Not even if all material were uniform in size and weight, would this be strictly true, and for mixed material it is less so. The finer material would reach the dam and there accumulate, whereas the coarser grades would lag behind, the surface soon forming a curve with the steeper grades farthest from the dam. The laws governing the movement of material are not simple; they are not purely functions of velocity nor of depth, though influenced by both. Observation shows that, except for fine material, transportation is only in small degree effected by suspension, being principally a forward movement along the bottom, largely a rolling motion of one particle upon or over another, and to this extent wavelike, but more particularly determined by bar formation first and undercutting later on. New forces constantly come into action, smaller particles aiding to move larger ones. It is therefore inexact to regard any slope as one of absolute equilibrium for a certain material, or to assume that one velocity will just move it and a slightly lesser one will not. It is nearer the truth to say that within limits one gradient, or a given velocity, will suffice to effect transportation less rapidly than a somewhat greater one, but there certainly remains a margin within which more or less rapid movement is possible. Even where gradient and surface elevations show no change, it is not safe to conclude that no movement is taking place, for it may only be the equilibrium of change, well adjusted removal and resupply.

Again, it might be argued that with mixed material the storage would be determined by the final surface of the coarse deposit, for, granting time enough for operations to continue and a sufficient supply of material to be acted upon, such would be the case, an eliminating process gradually leaving only such material at the surface, the rest being washed away. This process is important and is observable at all points where rapids or riffles maintain themselves. These are also natural barriers, acting to settle material above them, and as grade destroyers, and as such are serviceable. Again, where cutting is taking place, the action finds a limit, for cobbles accumulate upon the surface and prevent further change.

Next to vegetation, where vegetation is practicable, this eliminating process is important as a remedial agency, and no better illustration of its influence could be desired than the surface at the Narrows.

With fine material, or material relatively small compared with the moving forces, transportation takes place principally by suspension, and particularly so when the stream is not overcharged with sediment.

These reflections engender doubts whether the finest material would permanently lodge near the surface, at least near the dam, considering the torrential current during floods. Even allowing for the increase of width at the proposed crest level, including spillways, the lower end of the basin would be a long, narrow channel, the flow in which would at times be violent. The influence of this action might extend considerably below the surface, carrying sand and, perhaps, gravel over the crest or through the waste way. This would not be satisfactory storage, and it is doubtful whether as good efficiency could be expected as is obtained at the local impounding works at many of the mines, from which slimes and earthy particles escape only in small percentage.

Such action was observed by Mr. Luther Wagoner on the Tuolumne River. Soundings made just after the flood of 1890 showed the canyon to have been swept to bed rock for more than 1,000 feet above the Wheaton Dam, though before the flood sand and medium gravel extended to the dam, the canyon at this point being about 125 feet wide.

The maximum flood discharge for the Yuba River was assumed at 125,000 cubic feet per second, the same amount as was determined for the Tuolumne River. High-water marks can not be used to estimate the discharge of the Yuba River, owing to the unknown bed conditions. The Tuolumne River does not present this difficulty, and the flood marks of 1862 furnished data to estimate its discharge.

The watershed of the Tuolumne River above La Grange Dam is 1,501 square miles; that of the Yuba, above the Narrows, is about 1,175 square miles, but its shed extends into a belt of greater precipitation than does the Tuolumne River.

The plan of the dam shows ten openings in the waste way, each to be 14 feet wide by 25 feet deep, and a crest weir 320 feet long by 5 feet in depth. Assuming 13 feet per second for a velocity of approach, which the conditions above the dam warrant, the assumed maximum flood of 125,000 cubic feet would pass the dam at a depth of 4 feet on the weir crest, or at elevation 394 feet, still leaving 1 foot below the end walls of the structure. Four feet of water passed down the protected face of the dam does not seem excessive, as it is probable that water in the pool below the dam

would then stand at least at level 320 feet, being held at that level by the lower barrier and the throttling action in the gorge below.

Sheet 3 shows the velocity conditions which might be anticipated during the flood at the crest of the dam and at the barrier, showing an uninterrupted flood wave at the latter point. The effect of eddies, which can not be estimated, would be to increase the depth of water pool, furnishing additional protection.

But it must not be forgotten that these conditions are to be secured at the cost of providing a large waste way with bed at level 370 feet, and that the estimated storage at this level is 35,000,000 yards on the assumed 15 feet per mile gradient, and for a 5-foot and a horizontal grade, 16,000,000 and 11,500,000 yards, respectively. If it be further assumed that a certain pool depth below this level is necessary to avoid inductive action upon fine deposits, the amounts would be even smaller. If we attempt to close the waste way and to augment capacity, it can only be by forcing more water over the dam and less through the by-pass, exposing the dam to greater risk.

It might, indeed, be practicable to close the waste way by a masonry apron extending up to 390-foot level, and correspondingly to build a solid masonry addition or dam 20 feet high on top of the dam, holding a level of 415 feet, thereby shutting off all flow over the face and discharging only through the waste. This would increase the storage to the estimated 55,000,000 figure, but would add about $70,000 to the cost, and the expediency of this step, from a constructive standpoint, would depend upon the nature of the rock actually developed on the hillside of the waste way, and might, therefore, be practicable or not.

Comparing the storage estimates with the expectations raised by the earlier examinations, we find: First, that the extreme storage of this dam will not exceed 55,000,000 yards, and may not be quite 35,000,000, whereas the former estimates (House Ex. Doc. No. 98, p. 88) placed no limit below 260,000,000 yards, at an estimated cost for a set of barriers 225 feet high of $995,840, or an average cost of 0.39 cent per cubic yard stored; second, that figuring upon a dam 100 feet high, we find the capacity limited to 35,000,000 yards, at a cost per yard stored of 1.43 cents, against an expectation of over 50,000,000 at 0.61 cent; finally, that at our extreme limit of 55,000,000 yards, the cost would be 0.91 cent if the dam were filled to its top.

Retrospective.—Referring to the introductory remarks, it may be pertinent to explain that plans were first drawn for a dam to level 450 feet, then for one to level 425 feet, and finally for the dam figured on in this report. Beginning immediately after the completion of the contour map, various estimates were made as data were obtained, leaving open subjects in process of determination by prospect work, the higher dam being considered first, and the height being gradually reduced, as by that work some unfavorable discovery demonstrated the necessity for a lesser height. The idea was that the maximum height should so determine the lines of the structure that its location should not preclude a dam being ultimately built to that level, though the cost should exceed present appropriations. It was only thus that the maximum amount of storage at lowest rate of cost could be obtained, the necessity for an exact location in the present case arising from the limited areas of good abutment at the part of the canyon where the widths are narrowest. Whatever the height, the gravel base of the dam was to be wide enough upon the upstream side to permit a slope being carried up to the finished top. To establish the maximum storage was of particular interest, for the relative superiority of the Narrows Canyon over any similar site on other rivers had been determined by previous examinations, and if satisfactory results could not be had here, it would be almost useless to look elsewhere for better results from high dams in narrow canyons.

Diversion projects—The unsatisfying conclusion of the storage inquiry had been anticipated early in the work, and it was not difficult to see that the trouble lay in the small storage for fine material. Were this disposed of, the coarse material would cause less difficulty, even in the canyons, though it is open to question whether the best place to care for it might not be in the main tributaries, where the watersheds are limited and where large amounts of coarse material still remain. Surveys were undertaken to establish, if practicable, a line of diversion for fine sediment, a flume or canal route, by which a part of the flow might be carried from the storage reservoir to some point beyond the Yuba River shed, there released or aided to seek its way to the natural basins bordering Feather River, or stored in earth-banked areas upon the plains. The proposed capacity was to be 1,000 cubic feet per second, an amount exceeding the autumn low-water flow, and not falling far short of the whole river discharge for eight or nine months in ordinary years.

Mining in the higher districts begins with the disappearance of the high-range snow, and is continued, by the larger mines owning water storages, until the middle of autumn, while at small mines located in the foothills, the mining season begins and ceases with the rainy season. Barring the late spring rises, when snow is melting rapidly in the mountains, the active period of mining corresponds with times of low or medium flow. The time of maximum pollution occurs when the river is lowest.

Admitting that the Narrows reservoir, when not filled too nearly to its top, would

be able to settle fine material during floods, it would appear that it might be used in a manner not before proposed, namely, as a temporary receptacle of fine material to be afterwards removed by the diversion canal. This material would not be allowed to accumulate over one season, thereby relieving the dam of a duty it would poorly perform, and making it a permanent storer of coarse material only. Under this arrangement the storage works would promise a utility much exceeding that of the original plan, this idea suggesting an amelioration, if not a solution, of the detritus problem, and of protection to the lower rivers.

The principle is that, keeping the canyons clear of fine material, floods would only find the coarse to act upon, some weight being given to the fact that during freshets the percentage of suspended matter is lowest, owing to dilution, and the rivers are then best able to care for themselves.

Especially would the results be good if local works were maintained at the mines with capacity to hold their detritus during high water in the river, even if permitted to empty their basins during the dry season. The transportation of fine material would thus be confined to low water, when its delivery to the diversion canal would be sure and easy.

A canal survey was made and a practicable route determined; first, in connection with a dam at contemplated crest level 450 feet. Later, another route was established for a dam with crest at 425 feet. Finally, the latter route was so modified as to answer the requirements of the dam finally proposed.

In the latter case the diversion tunnel will be seen to have its exit at level 359 feet, 11 feet lower than the waste way floor, the occasion for which arrangement will be later on explained.

These surveys were of the character known as "careful preliminaries," and adhered closely enough to a final location to furnish approximate estimates of cost. The main features of the lines are closely similar in their upper portions, and only over the last 2½ miles do they diverge into two separate routes. The total length by each line is very close to ten miles, and the grade allowance per mile for the canal portions in excavation would be 7 feet per mile, with materially steeper grades on tunnel and flume sections, in order to reduce dimensions. Each line would leave the dam by a short diversion tunnel adjoining the waste way, would follow the cliffs in a flume on the left side of the canyon, would then become a canal or ditch of large dimensions, and at the beginning of the second mile would pierce the Timbuctoo Point by a tunnel, after which the canal would be resumed, and at the crossings of ravines or waterways flumes would be used. The estimates of cost by each of the three routes differed very slightly, the increased trestling and flume work and the more rocky nature of the higher line almost exactly compensating for the longer tunnel required for the lower route.

A map upon sheet B, which accompanies the second part of this report, shows the relative positions of the Yuba and Feather rivers, a portion of Bear River, and also the drainage of the included district, which consists of rolling hill land, in the easterly part passing into cultivated plain, the off-flow from which is collected by three water courses which unite not far from Reeds Station, on the California and Oregon Railroad, and then pass on to a junction with Feather River near Plumas Landing. General contours of the country, taken from the published sheets of the United States Geological Survey, are indicated upon the map, also the line dividing the Yuba and Reeds Creek watersheds, and the course of the two canal routes is shown with approximate accuracy. The upper line will be seen to terminate in the southerly half of sec. 36, T. 16 N, R. 5 E., near the middle line of the section, passing into the Reeds Creek shed at a ridge crossed by the Marysville and Smartville stage road, just west of the wayside house known as the Brady Ranch. The lower canal route passes two saddles near its lower end, the second one of which terminates the canal near the southerly end of the line dividing sections 34 and 35 of the same township. In each case there would be a free drop from the end of the canal into an arm of one of the forks of the northerly branch of Reeds Creek, known as Bull Run.

The following is a statement, in condensed form, of the several items which make up an estimate of cost of the lowest canal project between the Narrows Dam, as finally projected, and the terminal of this upper division of the diversion project:

Estimate of cost of diversion project from Narrows Dam to entrance of Reeds Creek watershed.

Dam accessories:	
Piers for waste way and masonry apron between piers	$16,350.00
Intake tower and wing walls, including 20 feet of hill wall of waste way and cost of excavating channel way leading to intake tower	9,534.25
Bridge over waste way, regulating timbers for waste way and intake, including operating tackle and cost of housing bridge and intake	5,500.00
Masonry retaining wall on hill side of waste way	7,100.00
Total estimated cost of dam accessories	38,484.25

Diversion project proper:

Diversion tunnel and inlet, length, 350 feet, including masonry retaining wall at exit portal	$19,176.00	
Flumes and trestling between diversion and Timbuctoo tunnels	52,094.63	
Grading for flumes and excavating canal between diversion and Timbuctoo tunnels	77,502.90	
Timbuctoo tunnel and approaches; length of tunnel 2,640 feet	135,000.00	
Flumes and trestling below Timbuctoo tunnel	34,961.56	
Canal excavation below Timbuctoo tunnel	252,798.00	
		$571,533.09
Total estimated cost of diversion project on a basis of 1,000 second-feet delivery		610,017.34

In this estimate are included items headed "dam accessories," all of which are shown upon the drawings of the Narrows Dam, and which may appear to be more properly chargeable to the cost of the dam than to the diversion project. It is otherwise, however. The items all relate (as nearly as it is possible to classify the work) to the waste way, and to purposes of regulating or directing the flow from the basin. They are properly chargeable to the diversion project for were it not for it no piers, no intake tower and channel way, and no regulating tackle would have been required, and the hill wall of waste way would have been much less costly. The estimate of the Narrows Dam included the expense of the additional excavation made necessary by the introduction of piers, but if the dam were to be regarded as a separate project, without a diversion system, then the cost should be considered as something less than $500,000 instead of $515,389.83, as estimated.

The canal would transport large quantities of silt and sand long distances under somewhat experimental conditions. To insure success it would be necessary to allow for very liberal dilution to prevent blockages in the conduit. Two per cent solid matter, by volume, was considered safe to figure on, experience with sediment-laden water samples warranting this assumption, particularly if provision were made to supply clear water to flush the conduit, if found necessary. Upon a basis of 1,000 cubic feet per second capacity in the canal, the amount of water for a twenty-four-hour delivery would be 86,400,000 cubic feet, 2 per cent of which would represent 64,000 cubic yards of sediment daily, or in sixty running days 3,840,000 cubic yards. Assuming that in an average hydraulic bank one-fifth might be material of the character transportable in the conduit, the last-named amount would represent 19,200,000 cubic yards in place. This is more than the quantity formerly figured on as likely to require storage annually, at the time when hydraulic mining had attained its greatest development and when the estimated output was about forty times that of recent years. Sixty days would be a very short working season, from which it might appear that the canal had been given needless dimensions, but the intention was to have it carry all the water in the river for as long a period as might be economically practicable.

Under the arrangement shown on the drawings (sheets 2 and 3) the tunnel would carry off the estimated 1,000 cubic feet of water automatically, without necessity for closing the waste, but at times of low and medium water, by partly closing it and the tunnel inlet, more favorable conditions might be produced, aiding dead water and increased deposit higher up in the reservoir, if so desired, and facilitating scour at the tunnel entrance and near the dam.

It has been stated how the action of floods upon fine deposits near the dam might be unfavorable and extend considerably below the surface, and besides the instance cited at the Wheaton Dam other cases have been noted where the effect of such action has been marked. Let it be assumed, for instance, that after completion of the dam experience should determine level 350 feet, or 20 feet below the waste way, to be the safe top limit to allow fine material to accumulate. The storage table shows at this level, upon the grade for fine material, a capacity of less than 8,000,000 yards, of which amount the larger part would be coarse material. The diversion project was suggested as a remedy and piers were introduced as a feature thereof, in doing which, however, the following manner of utilizing the power resource at the dam was thought of for making the basin do repeated duty in collecting fine sediment, thereby prolonging the utility of the whole storage system.

The piers and regulating timbers would supply means of holding the reservoir surface at a constant level, for instance, 390 feet, giving a fall of 23 feet to the water surface below the diversion-tunnel exit, approximately at level 367 feet. This represents a considerable power. The power could be used to siphon mud accumulations from the bottom, drawing these to the surface and delivering them through a pipe to the flume below the tunnel, where enough water from the reservoir would be added to produce the necessary dilution for proper conveyance in the

canal. Thus the fine deposits might be removed during each working season, using the reservoir only as a temporary receptacle for them.

Theoretically, no power would be required to do this work, but in practice it would amount to a very cheap method of pumping. The plant would be simple and inexpensive, and would consist of one or several such pipes distributed along the bank for some distance from the dam, half a mile if necessary, or a scow could be kept plying the basin with requisite pumping machinery mounted upon it.

Reeds Creek surveys (see map on sheet B, accompanying second part of report).—In November, 1898, a reconnoissance survey was made, starting at the tenth mile, or terminal, of the diversion canal, this examination covering the two branches of Reeds Creek. From the tenth to the thirteenth mile (distances being reckoned from the Narrows), the line drops rapidly, about 120 feet in elevation, to a point in the Bull Run water course near the middle of sec. 10, T. 15 N., R. 5 E., up to which point no works would be required, the route following a natural water course. From here, continuing down Bull Run, a line of levels and cross sections was extended to the 21½-mile point, the entrance of the middle branch not far above the point where Bull Run passes the railroad. Work was then resumed at the thirteenth mile of the survey, and a line run southerly across a low intervening mesa to a point near the fifteenth mile, where the slope begins to fall toward the south arm of Reeds Creek, from which the survey followed down this branch to the junction of the three forks below Reeds Station, and thence down the united courses to the wagon-road grade between Marysville and Sacramento, at 2,200 feet beyond the twenty eighth mile. Both courses follow broad, swale-like troughs, or valleys, in the rolling country which is drained by them, the land and also the drainage depressions having slopes of 20 feet for the first couple of miles, decreasing to about 5 f et per mile near the railroad.

Almost any portion of this territory might be used to store sediment on, but the examinations upon the whole failed to reveal any natural repository peculiarly adapted to the purpose, except in one sense the area marked "settling basin" on the map. Here there is an area of bottom land of some extent having upon either side natural banks 12 to 16 feet higher than the bed of the stream, and which is shut in on its third side by the wagon grade. But the capacity of this basin is not large enough to be of great consequence, and its value is problematical, as it lies entirely below the level of extreme backwater from Feather River, and besides, objections exist to its use on the score of the large volume of drainage carried by Reeds Creek after heavy rains.

The lower portion of the Bull Run water course is open to like objections. Well-defined banks are lacking and the adjacent land is often overflowed, conditions which would only be intensified by filling up the water course with detritus. The south branch flows on higher ground and is not open to the same objection. It receives less drainage, is better banked, has more uniform dimensions, and would be well able to carry all the water furnished by the diversion canal, but there is no surplus area within banks which could be utilized for storage purposes without detriment to present conditions. Upon the other hand, it leads to no place where more advantageous conditions are presented.

For storage a plan would have to be developed, using embanked ponds or tanks, located upon mesa lands or plain, which it is believed would work out with a fairly low cost of storage unit, probably not exceeding 1½ cents per yard in the beginning, reducible to about two-thirds of a cent a few years later. These figures are intended to cover cost of lands and embankments, and ultimately the distributed cost of the flumes, canals, and laterals required to dispose of the material after entering the Reeds Creek shed, but in the latter case only for operations covering a period of years. Comprehensive detailed surveying would be required to determine the most eligible areas.

Notwithstanding the conclusion regarding the probable cost of impoundage, the conditions developed by the Reeds Creek surveys did not quite realize anticipations. The ground is too undulating, the desirable tracts too much apart to furnish a concentrated body of tanks, and the point where storage operations would commence is not approached with a sufficient surplus of elevation to make it sure that trouble would not be met, owing to accumulations of sediment collecting near the point of release from the main conveying conduit. These are difficulties which it might require some study to overcome and which are not desirable features in an undertaking of an original character such as this sediment-disposal problem is. But before this conclusion was reached, investigations in another locality showed the probability of better results elsewhere. These are described in the second part of this report.

SURVEYS AND PROJECT OF 1899.

(Attention is invited to accompanying sheets, A, B, C, and D, illustrative of this part of the work, and also to cross-section sheets 1 to 4 and a to d.)

Field operations were commenced December 20, 1898, and it was soon demonstrated that a diversion canal, similar in its purpose to the canal lines surveyed from the

Narrows, would be practicable, leaving the river not far below the Parks Bar Bridge, 5 miles below the Narrows. This route avoids necessity for the objectionable Timbuctoo tunnel, is able to reach the same territory, traversing far smoother ground, and in its course passes within easy reach of a large body of almost level land possessing all the qualities sought for but not found in the Reeds Creek territory.

The scope of the examination soon broadened, maturing into a project for general improvement and control of the Yuba River, applying remedial treatment from the Narrows to the mouth. The canal may become a desirable adjunct to the project, but may be dispensed with and is only incidentally mentioned at this time.

During February, 1899, a scheme of works was blocked out, the features of which have undergone little modification by reason of examinations made to test its practicability. Field operations have been continuously in progress up to the beginning of November. The surveys comprise an examination in detail of the present conditions and a comparison with all procurable authentic data collected in former years. The results are presented in much condensed form upon sheet A, which is a map of the river accompanied by profiles, and by sheets 1 to 4 and a to d, which contain 51 cross sections disposed between the Narrows and Marysville. The former set shows the changes between Daguerre Point and Marysville upon sections originally surveyed by direction of the Engineer Corps in 1893 and examined periodically since then. The latter set presents cross sections first located by the State engineer department of California between 1878 and 1881, beginning at the old State Dam and extending about 7 miles up the river, and also additional cross sections located in 1899 above the point where previous surveys had established sections. The retracing of the old State surveys was coupled with some uncertainty, and successful only where the original posts were found. Being a process by trial, the original lines and the retraces did not always prove identical lines, to indicate which fact, though the differences were never considerable, a dotted or broken line in place of a full one was used on the drawings.

Beginning in the month of June, a force of laborers and miners, ranging from ten to twenty in number, was set at work and kept continuously employed while field operations lasted. The work consisted in sinking shafts and making excavations in quest of quarry rock, and to determine the formation where it is proposed to change the channel of the river, and in borings in the river bed at points where it is proposed to locate structures. The localities will be sufficiently clear upon an examination of the maps and drawings, and the more important results are there recorded in sufficient detail to render tabulated statements unnecessary in a general report, progress reports of the work being available for office reference.

Between levees and in the river bed, from Marysville to the Narrows, there is comprised an area of about 15,130 acres, disposed as follows:

	Acres.
Private holdings, or lands in process of private acquirement	11,889
Unsurveyed public lands embraced within the official meanders of the river.	3,131
Withdrawn from entry at request of California Débris Commission	110
Total	15,130

(All figures closely approximate.)

The map shows these lands—

	Acres.
Stippled, to denote areas of shifting sands and gravels, about	4,310
Uncolored, and intended to denote brush lands, about	10,820

From the Narrows to the mouth of Dry Creek, about 8 miles, is one uninterrupted waste of sand and gravel deposit, the whole width between banks being occupied as one channel way during floods. At Dry Creek brush lands begin and predominate below Daguerre Point and below the old State Dam on the south side of the river, appearing as islands between channels and cross channels, and for the most part consist of river silt and sand thickly matted with roots, a product resisting cutting by water, often maintaining vertical banks 8 to 9 feet high, which do not cave. The ground is usually perceptibly higher bordering channels, and recedes therefrom, in the lower reaches of the river forming large basins of depressed land entirely submerged at flood time, a condition produced by the throttling action of the contracted waterway at the Marysville bridges.

Casual inspection of the drawings will of itself suffice to produce the impression of conditions abnormal and irregular, the irregularities becoming most striking at times of high water, the evidences of which during the floods of March, 1899, were noted with care. An attempt has been made to show these (see sheet A, profile), in examining which allowance should be made for the effects of foreshortening not avoidable where lines of unequal length are sought to be brought into comparison.

Here an indication is presented of how bodies of water become divided or unite;

how bodies of slack water are found not remote from arteries of rapid flow, and how at points of the same cross section great differences of water surface are found. At this stage it is a case of several rivers flowing within the body of one river. Cross currents for the time become principal currents, and one case may even be instanced of a river practically flowing back upon itself.

Here, also, explanations suggest themselves for the unequal rate of deposit, partly owing to the effects of scour, or how water pockets for a period of years may preclude access of new material and prevent land building until general conditions change. But these depressed basins cause the set of the medium-stage channels and define the low ones, which may again be diverted to right or left, as bars are formed or cut away.

From Dry Creek to Daguerre Point there are two, and below the latter three channels, one central, closely conforming to the original Yuba, and one hugging each of the levees built to inclose the river upon its sides. Each of these has in turn served as a principal channel during low waters. Each begins at the skirts of a talus of deposit which terminates in the vicinity of Dry Creek. They soon occupy ridges which they themselves have occasioned, and they inclose areas of lesser elevation between them. Conditions favoring sudden or rapid bed alterations maintain themselves at one vicinity or the other, and it is manifest that levees are jeopardized in ways impossible to foresee. Still, it may be noted that it has been local custom to closely peg high-water marks and to regulate additions to levees by this guide.

In fact the very width of the river has been a principal source of danger. Left unregulated, it has had too much room for change, a point which may be noted in planning for its government.

In dealing with conditions so irregular, generalizations do not readily suggest themselves, nor are they warrantable except with proper qualifications as to fallibility. Even the results of surveys are to be accepted with caution and require careful interpretation. An illustration of this is furnished by the cross sections of the river at Marysville, both at D street and at the railroad brige (cross section, sheet 4). It has been the custom to make examinations of the river at D street annually, always, and quite consistently, at the extreme low-water stage, during autumn, to note progressive change. That a filling has been going on here is not to be questioned, the extent of which between the extreme periods of observation, 1878-79, and 1899, is shown upon the exhibit. It has been thought proper, however, to show the conditions here not only at the low, but at the flood period also, the surveys being, for low water, December, 1878, and September, 1899; for floods, April, 1879, and March, 1899, the older data being from surveys of the State engineer department, the 1899 surveys our own. In both instances it is quite manifest that the changes between the high and low water conditions of the same year or season by far exceeded the total change which has taken place between either the high or low water conditions, each with each, for the whole period of, say, twenty years. Upon the railroad-bridge section is also shown the condition of the river at the time of the original survey for the road. It is from notes found among the data of the State engineer department. Its date has not yet been ascertained, neither year nor water stage, but portions of the road between Marysville and Sacramento were surveyed as early as 1861. The road was completed to Marysville in 1868.

Taken as a whole, these sections should be reassuring, especially to residents of that city. The cross sections of lines 1 to 19 show, for 1899, low-water sections (August-September). Between Marysville and Daguerre Point our surveys were made north of main channel before high water of March, 1899; south of main channel, during high-medium stage following the flood. It should therefore be noted that the proportions of water-carrying channels shown upon the map, on sheet A, correspond to a period of more than normal flow, perhaps exaggerated near the Linda Levee as regards the opposite side of the river, and especially so when compared with the portion east of Dry Creek, which is from surveys made later than July, 1899. But what is of more importance is that when the high-medium water stage survey was made soundings of the river were attempted, which were supplemented by measurements taken at a later date, mainly because the first gaugings had been taken under great difficulties, and only showed depths occasionally. Still, what is to the point, is that uniformly from section 10 to section 16 all these soundings agreed in showing from 4 to 6 feet greater maximum depths than during the following autumn. This fact is noted as testimony that scour of the channel may be safely counted upon as easy to maintain should the river flow be properly confined.

In attempting to digest the more important changes of conditions which have transpired, data are less complete than could be desired; yet the changes appear to have conformed to certain laws of regularity, and to be less erratic than might be anticipated. Above Daguerre Point up to a point marked "barrier No. 1" on the the map, we have a very satisfactory record covering the year 1880–81, but no information at all from that time until the present surveys were made. From this point to the Narrows we have only fragmentary records at several points, containing

information collected (all under the same observer) at various times between 1878 and 1882. Ignoring time distinctions during this relatively brief interval, a fair composite record may be compiled; but we possess no information of changes from that time till 1898–99. Between Daguerre Point and the site of the old State Dam, we have the records of 1880-81, supplemented by additional data collected between 1879 and 1880. All this when put together furnishes a fair exhibit of the whole river to the Narrows, giving information not only as regards bed elevations, but also as to the altitude of the high-water plane. This information may be found upon the profile of the river (sheet A). Compared with the corresponding data of the present year, there appears a general conformity well calculated to invite confidence.

From Daguerre Point to Marysville we have almost continuous records beginning with 1893 (United States engineer records), but except as stated no information of an earlier date except at Marysville and that shown for a small distance into the river, by a State engineer section, which is noted upon our cross section No. 13 (sheet 3), with which that line happens to agree almost exactly in location. This section constitutes the only piece of work done inside the levees by the State during that examination which is available for comparison, and shows a local fill during twenty years of about 12 feet (maximum) at one point between the old Teegarden Levee and the Browns Valley grade, and of about 8 feet just outside that levee, diminishing to 2½ or 3 feet as the river channel is approached. Correspondingly, a rise of 4.5 feet and 3.5 feet at these points is shown in the high-water planes of 1878–79 and 1898–99, both years of more than average freshet, and properly comparable.

High-water gradients, it will be observed, are valueless except when the exact points of observation are noted and the distance between the points, upon which the rate of gradient is based, is stated. Our high-water studies observe this condition. As regards the slope of the tailings and of the brush-covered lands, these are tolerably constant for considerable distances, except, naturally, as regards the differences between high and low land on the same cross section. One is less restricted, through fear of inexactness, to special distances in discussing these.

The deposit along the course of the river has been by no means uniform. Neutral points or areas exist where deposits disappear about as fast as they are formed. A short distance below the Narrows appears to have been such a point, a fact to be explained by the presence of the Smartville dump, which has acted as a dam by reason of the cobbles here entering the stream. The canyons above the Narrows are known to have discharged large bodies of material during the past twenty years, having either cleared themselves or worked their surfaces down to a plane of comparative rest, but at the line between subdivisions 27 and 28 of T. 16 N., R. 6 E., just above the dumps, the tailings are now only 3.4 feet lower than during 1882. They were at elevation 296.1 at this point, and now stand at level 292.7 feet.

Again, consulting cross-section sheets 1 and a, there appears to be undoubted evidence of a belt of similar character below Daguerre Point, and in the vicinity of the old State Dam. Cross section II, which closely agrees for a part of its length with section 3, on sheet 1, shows the same average level that it did twenty years ago, the sum total of all the changes balancing exactly. Section I would appear to indicate an average fill of 3.5 feet, but the survey of 1899 traverses what was once the old brush dam, and is above the general level. Section III, which is at Daguerre Point, shows an average fill of 1.5 feet since 1880; while, if we consult sheet 1, showing sections 1 to 5, we see that since 1893 the changes have been slight, there being practically no alteration north of the central channel. Land building has been going on more extensively toward the southerly side, but usually has not exceeded 1 foot. Line 4 particularly shows little change of surface. Some cutting has taken place at the southerly end of these five sections, and an important channel has developed itself toward the south side, turning into the central channel above the old State Dam.

This local balance of action is probably due to conditions occasioned by the deflecting action of Daguerre Point, controlled to some extent by confining influences still exerted by the old brush dam, and, upon the opposite side, by a barrier built in 1896 under direction of the United States engineers.

Proceeding eastward from Daguerre Point, sheets a and b show increasing rates of deposit. At Dry Creek the mean fill since 1880, shown upon section IX, and measured between horizontal lines of average elevation, is 6 feet, increasing as the river is ascended till at section XVIII, at a point designated "barrier No. 1," the fill during the past twenty years is 13 feet. Here it appears to have attained maximum depth. An estimate of the total fill from the State Dam to this section, from 1880 to 1899, is 25,790,000 yards, and from this point to the Narrows it is probable that the fill for the same period is overstated by the figure 7,847,000, making a total of 33,637,000 yards. The last approximate figure is obtained by applying to the surface areas of 1899 the amounts of filling shown since 1878 and 1879, as far up the river as the information regarding those years is available, namely, to Timbuctoo dump where the fill is 9 feet; by then assuming that the depth of fill, instead of decreasing beyond

this point, remained uniform around the whole sweep of the horseshoe bend, and only in the last 4,000 feet ran out to nothing at the Smartville dump. Calling this result the fill since 1880 is manifestly a safe estimate. As regards the gradient of the deposit, the distance from the line between subdivisions 27 and 28 and cross section XVIII is 27,200 feet, and from here to cross section IX, at Dry Creek, 13,000 feet. The average slope for the upper reach figures out 18.9 feet per mile, and for the lower reach, 19.1 feet per mile in 1899.

In 1880 the slopes appear to have been respectively 22 and 16.25 feet per mile; that is to say, the upper reach, which was formerly the steeper, has become the flatter of the two. With a total fill taking place of 13 feet at section XVIII, we have now a slight hump in the slope, whereas it was formerly a decided dish, and it will be observed here that, at this spot, which is an important point in the system of works to be proposed, during the past twenty years, notwithstanding unfavorable action maintained below it, material has been deposited, not cut away, and this, moreover, during a period when the amount of new material to build slopes has been year by year diminishing. It is not necessary to argue that were the supply of coarse material altogether stopped below this section, no flattening of the slope between it and Dry Creek would follow, but only to gain assurance that if the tendency were to flatten, the reduction would be brought about gradually, and not more rapidly than would afford opportunity to regulate the rate of change if it showed a tendency to alter less gradually than were desirable. It is proposed at section XVIII to build an important barrier, and it is important to guard against removal at a rapid rate of deposits below the toe.

It may now best answer the purpose to refer to the map showing the conditions between here and Daguerre Point, and between the latter and the old State Dam.

Midway in the basin, opposite Dry Creek, but slightly west of it, will be seen an island, which, lacking a distinctive local name, will be designated "Pine Island" in this report. The island extends west about 5,000 feet, with a maximum width of 1,500 feet. Most of its surface is now "slickens" deposit, and it is heavily overgrown with tall willows, but at the head of the island there are a few acres where the natural black loam has never been covered, and where there is a growth of scattering pines. A few inches below the surface is cobble gravel, no modern deposit, but part of the ancient gravel channel which constitutes the body of Daguerre Point, and which appears on the left bank of the Yuba, where it has been mined over for several miles above Pine Island. On Pine Island it consists of well-compacted cobbles, and where the bank crops out at the river channel it maintains itself vertical, little affected by the strong currents which are directed against it. The original channel of the Yuba River passed to the south of the island, between it and the mainland on the left shore. The island is the terminus and the last visible portion of the promontory of high land which formerly defined the right bank of Dry Creek and its mouth. Not until after the great flood of 1861–62, it is said, did water pass to the north of Pine Island. Now, everything to the north of it is a flood channel, down the course of which passes a low-water channel almost equally prominent with the channel south of Pine Island. At the lower end of the island each of these is cross-connected with the other, but the main north channel heads straight on for the depressed land above Daguerre Point. The test pits and borings shown by cross sections VII and VIII, on plate b, give a good idea of the subsurface conditions and of the nature of the deposits. One of the high-water studies shown with the profile of the river indicates the erratic combination of flood gradients along the north and south channels, notably the steep gradient of 26 feet per mile leading into the south channel and flattening out toward the west, and the flat gradients in the comparatively still water on the north side, just below Dry Creek, and in the flood-water pocket above Daguerre Point.

Isolation and the absence of high-water currents in this pocket and along the north shore below Daguerre Point nearly to cross section No. 7 show visible effects on the map contours and also on the corresponding portions of all the cross sections. The land has refused to build. This fact has been a constant source of danger to the Marysville levees. Attention is especially invited to cross section IV, which was originally run in 1879. It connects Daguerre Point, south (the actual Daguerre Point), with the promontory on the north side of the river, which in all the reports is alone designated by the name, though locally not much associated with the name Daguerre. The section appears to cut the basin obliquely, and for part of its course it now defines one of the principal cross-basin channels, and in 1879 did so in still greater degree, and in so far partakes more of the nature of a profile than a cross-section line. The characteristics have undergone but very slight alteration, but it does not legitimately represent the fill, the line being mainly on bank in 1899, while it was in channel trough for most of its way when originally run.

The facts and data given supply material for a very fair conception of the forces which have run riot within the boundaries named. It will be seen how a talus of coarse deposits has planted its toe upon an island of nonerosive banks, flanked upon

either side by a river channel; that immediately in range with the skirt of the talus Dry Creek, a principal tributary of the river, directs its currents across the deposit, undermining its toe and permitting discharge through the north or south channel, as circumstances may determine, the one channel opening as the other closes, while below is found the depressed land causing the set of the current northward, only to be deflected by Daguerre Point. Then the old State Dam turns the current northward again, but contains openings through which the waters are discharged when the passage to the north fails from any cause to carry the flow. To round out this picture there must be added the conception of alternating low-water and flood conditions, each one ready to take up the work where dropped by the other; one working slowly and persistently, the other violently and by rush, but always in accord. And so on, but now mainly affecting lighter material; on, through the several reaches between the State Dam and Feather River; from channel to pool, and pool to channel, crosswise of this large settling basin, which at haphazard has been formed within the embanked lines of the district, the river makes its way. Small wonder that things have never come to a state of rest.

These conditions have been enumerated in detail because it is with a view to their removal or control that the system of works now to be described has been planned. All the works, as far as they have yet been given form, lie above the line of the old State Dam, and they may, therefore, be properly described before considering the changes which have been going on below that line.

The programme is to treat the river in subdivisions, which may be briefly enumerated as follows:

Division I, to extend east from barrier No. 1 and to be the receptacle for coarse material—that is, material too coarse for successful handling elsewhere.

Division II, extending west from barrier No. 1 to Pine Island. No works are contemplated, the object being to check erosion and to guard the slope conditions.

Division III, which is to be longitudinally divided into a northerly and a southerly half, extending from Pine Island to Daguerre Point and the State Dam, respectively. The latter is to serve as a clarifying basin and receptacle for fine sediment; the former is to be set apart as a flood-overflow channel intended to carry water during flood. A rock-faced embankment extending from the head of Pine Island to the line of the old State Dam is to form the division between settling basin and flood channel, and the flow through the latter is to be passed direct to the present main channel below Daguerre Point through a cut to be made through that promontory, thus making an almost straight alignment from Dry Creek to the main river channel where it now passes the old State Dam.

Division IV may be understood as comprising everything west of Division III, and extending to Feather River.

The southerly line of the settling basin is defined by high land and by the Linda Levee, which would in course of time require raising and strengthening. The basin is shut off at its head by a rock-faced embankment extending across the south river channel between Pine Island and the shore, which is perforated by four sluice openings disposed in two pairs, each pair to have sufficient capacity to admit, when the passages are open, 3,000 second-feet, or a capacity about equal to the average winter flow of the river when not raised by storms.

During floods, or at other times if desired, the openings into the settling basin may be closed. Flow will then be all through the flood channel, across the entrance to which there is to be constructed a rock-filled crib-work barrier extending from a junction with the inclosing levees of the basin northward to the main shore below the mouth of Dry Creek, a distance of 4,000 feet. The proposed crest elevation of this barrier is 146 feet, 4 feet higher than the level of the inlets to the settling basin, 4 feet lower than the inlet embankment level at the junction, and 6 feet below its height where it crosses the channel south of Pine Island. This last-named difference of 2 feet is a provision for the safety of the more important portions of the embankment, close to the inlets, but it is estimated that the maximum flood volume will pass the barrier when flowing 2.5 feet deep, or at level 148.5 feet, still leaving 1.5 feet of margin before the embankment at its lesser height could be overtopped, and overflow into the settling basin begin, which is not contemplated. The purpose of the barrier across the flood-overflow channel is three-fold; first, as a regulator and equalizer of the discharge at times when water is passing over it; second, as a diverting structure to maintain the necessary level in order to insure flow toward the basin when so desired; third, as a grade consumer and to aid the purpose specified as the requirement for Division II. On the map it is referred to both as "diverting barrier" and as "flood-overflow barrier," but they are used as synonymous terms. Its action is automatic, but the structure is so arranged that its height may be slightly added to or lowered by trifling alterations, which arrangement may be availed of should experience show that a slightly inclined crest, or even an irregular elevation for the overflow, would best conform to actual requirements.

The cut at Daguerre Point is to have a bed width of 430 feet in the body of the cut and 600 feet along its entrance, which is to be an unobstructed drop over a wall

and apron of concrete, the crest of which is to stand at elevation 127 feet. From the end of the promontory a barrier is to extend south 3,000 feet, to join the embankment on the north side of the settling basin. Its crest line for the first 1,000 feet is to stand at elevation 129 feet, then rising 5 feet in the following 500, and finally joining the basin levee at elevation 136 feet. Here the crest is intended to stand 2 feet above the level of any flood to be looked for at Daguerre Point, which is expected to be easily carried when water has reached a depth of 7 feet at the entrance to the cut and 5 feet on the barrier, running out to no depth at 1,500 feet from the north end. That is to say, after the cut has been finished and everything is in final shape; but during the time of constructing the barrier and before the cut has had opportunity to do full duty, the conditions will be otherwise, as will be explained. Provision will then have to be made for a flood wave passing over the whole length of the crest, which would probably be kept at uniform level to equalize the duty. Reference 127 is only slightly above the general surface level, and no storage is counted on above these works. The barrier is introduced principally to secure diversion through the cut and to divide the duty, the concrete entrance wall being only a repetition of the crib structure at Pine Island and intended to establish a fixed level. Concrete is selected in recognition of the favorable opportunities for its use in contrast with the semiperishable crib and stone work at Pine Island. Permanency is highly desirable at the lower works, but not essential at the upper ones, seeing that so long as the elevation is maintained below an alteration of the gradient above is possible only within reasonable limit.

Reviewing the structures thus briefly outlined in their essential features it appears that the unfavorable conditions which stand out strongly in the analysis are provided against. The opportunity for the maintenance of divided currents is removed by obliterating the south channel, and serpentine meanderings are prevented by confinement and direct alignment. And the works at Daguerre Point do duty also as a grade consumer.

A plan of Daguerre Point and an analysis of the structural formation of this interesting headland will be found upon sheet D, and a similar exhibit of the conditions at barrier No. 1 is shown upon sheet B. Both maps are of a like scale, and the sections alike as regards both scales, the vertical and horizontal. Comparisons are therefore easy.

Barrier No. 1 is a dam with a by-pass, the latter being the important feature. It is intended for storage of material, differing in this respect from the barrier at Daguerre Point, and is principally a diverting structure, for when completed it will have served its purpose as a storage device. But it is to act as the safeguard of similar barriers, of which in time there may be several, their special purposes being to store material and lessen gradients. The present project provides for only one such secondary structure, barrier No. 2. Its cross section is shown upon sheet B, and its proposed location upon the general map and profile.

In view of the importance of barrier No. 1 and the strategic nature of its duty, it should be provided with all reasonable safeguards; first, against undermining resulting from rapid changes of the river bed below it; second, in consequence of severe duty and the impact of torrential rushes of water from above. The latter point it is most easy to secure by reducing to the utmost limit the quantity of water likely to pass over it, and by reducing its period of exposure. Both objects are attained by passing the river around the structure rather than over it. As planned, after its completion, and when the by-pass has come into activity, no water at all (barring leakage through its body) will pass the structure until the river has attained a flow of about 19,000 second-feet—already a flood. With an assumed possible flood discharge of 125,000 cubic feet per second, it is estimated that the relative quantities flowing through the by-pass and over the dam would be 70,000 second-feet and 55,000 second-feet, and that the respective depths of water on the two crests would then be 7 feet on by-pass, and 3.5 feet on the barrier, corresponding to a common flood level of 220 feet (absolute elevation). The duty per linear foot of lip of by-pass would be 117.6 cubic feet per second, and per foot of dam crest 50 cubic feet, with estimated average velocities of 16.8 and 14.3 feet, respectively.

It is hardly necessary to explain, in view of the argument made in part 1 of this report, that the intention would be to segregate the detritus into coarse and fine, retaining the former and passing down the stream the finer sands, the silt, and the slimes. The finer material it is, of course, intended to pass directly into the settling basin as fast as supplied, and retain it there, thus keeping the river free from accumulations of light matter for floods to act upon. This statement sufficiently describes the general plan of operations, and the details may now receive consideration.

A closing in of the settling basin at its lower end is necessary, and a barrier for this purpose is to be provided, the proposed location for which is to be at or very close to the line of the old State Dam. This would provide a settling basin 3 miles long, with a general width of about one-half mile. It would cover, within the lines shown upon the map, about 992 acres, and its estimated capacity is 14,469,000 cubic

yards, assuming a storage surface to be built up to elevation 125 feet at the lower end, and the deposit to grade back upon a slope of 5 feet per mile, corresponding to an elevation of 140 feet at the upper end of the basin.

The details of all the structures are to be found upon sheets B, C, and D. These are drawn upon a uniform scale, and are readily comparable as to size and dimensions. They are all simple constructions, and the scale is large enough to show their structure without need of a detailed description. The bracketed figures indicate the more important references, and heights are readily deducible by differences of level. The works cover such an extended line that it is absolutely necessary that they be for the most part constructed of material to be found upon the ground, or procurable without considerable outlay for transportation, and the very nature of the problem calls for gradual development of the works, construction being expected to keep pace with the requirements, but not to go far in advance of them. Even the gravel embankments of the settling basin and the flood-overflow barrier may conform to this requirement, though they are the works most likely to be built rapidly, which consideration caused crib work to be used rather than brush work in planning them. It is, however, only used where durability is not an essential condition, or in the case of the openings through the embankments, where, if the works were to be discontinued, the openings could be permanently sealed with rock at no large expense. The structures aiming to effect deposit all recognize the principle that it is absolutely essential, in order to insure an equal distribution of the deposit, that they be placed directly in the path of the flowing current and that a certain amount of water be allowed to flow over them without damage. They all employ brush work as mattresses or as low walls, and are heavily reinforced with rock or stone paving. Rock is intended to constitute the actual structure, but it is to be added by installments, and where low, broad walls are placed upon the rockwork, they are to be added only after subsidences have had time to fully adjust themselves. Ordinarily, where rockwork is shown it is understood to be rock whose interstices are filled with gravel or sand, if possible washed in by water. Except when used in mattresses the brush does not form an essential part of the structure, and its rotting is a contingency duly provided for.

Generally, the brush is intended to be used sparingly and only to the extent required to strain the water and to direct and distribute the flow. Brush thus used is a safe and desirable material, and it is not intended that there shall be a large height of brush exposed without being properly aproned with rock. Opportunity is offered for unfinished rockwork to be given a very flat slope until it has gradually passed from a mere revetment to the more perfect form shown upon the exterior of finished work. The low, broad-based cap walls of masonry are rock laid in concrete slightly finished in cement mortar, and are well-protected parts of the general structure rather than a separate element. Masonry laid on rubble used in this way is warrantable; for even cracking, should it occur from unexpected settlements, would not be a serious defect or one not easily made good. Especially are such walls used at barrier No. 1 to form water pockets to take up shock. These pockets are not to be necessarily water-tight when only a small amount of water is trickling over the barrier, as no special provision is made for tightness of their bottoms, but when the flow increases they will perform their expected duty. They are a flood provision, and it is not essential that they should act except when a considerable flow is passing. Barrier No. 2 is to be a higher structure than barrier No. 1. It is to be exposed to severer duty. But attention is directed to the respective elevations at the two structures after the lower barrier has been finished, when there will be a considerable depth of backwater below barrier No. 2; hence, adequate protection of its toe. During the time the lower barrier is incomplete, the upper one will not be exposed to serious attack if kept slightly above the tailings as they build up their surface. It will then be to the interest of barrier No. 1 to let it do all the storing, in order to facilitate its rapid construction and to promote speedy aid from the waste way.

Upon sheet D three sections of the Daguerre barrier are shown, which are similar, but provide for the varying degrees of service along different points, and, recalling previous explanations, the drawings should be clear as to the plan of construction. After completion of the works only the northerly 1,500 feet of the barrier will act as an overflow, but before then all its parts must carry water when floods require it. On the three sections the base, up to elevation 124 feet, is identical, and this level indicates the first stage of their progress. Figure 13, sheet C, shows the cross section of the barrier at the lower end of the proposed settling basin, or the "outlet barrier," which will be seen to agree practically in its first stage with the base of the three sections of the Daguerre barrier, although the tops are at different levels. But taking the two barriers conjointly, and remembering that their offshore ends are to be connected by an embankment, it will be recognized that together they constitute a dam across the whole width of the river basin, the length of which from shore to shore is practically 6,000 feet, not including embankment. With a crest of this length, the delivery per foot of barrier during the assumed maximum flood would

be only 21 cubic feet per second, and the present slope of the river is such as to warrant an estimated approach velocity of about 4.5 feet per second, making the probable depth of water about 27 inches. This is by no means a small duty, but with any ordinary flood no such exposure would take place. Prudence dictates, however, that the duties of the barriers be kept as evenly distributed as possible, and to effect this, equal amounts should enter the two channels at Pine Island. Some judgment must therefore be exercised not to throttle the south passageway before conditions warrant it.

The embankment which excludes the river from the storage basin is divided by the Daguerre Point barrier into an upper and a lower subdivision. Possible high-water complications in the north channel determine the heights along the upper division, and also call for liberal rock protection on its channel side. In the lower division there is more range for choice of height. It will be sufficient at the start that this portion of the embankment should meet the requirements before specified as a connecting link, and it may subsequently be raised to conform with storage requirements. Its cost is correspondingly reduced.

Within the limits necessary for substantial work Daguerre Point barrier may be raised without interruption; this is desirable to bring the cut into operation as soon as practicable.

The storage basin will need to be divided off into two parts extending along its axis, a north basin and a south one. These will, perhaps, have to be subdivided crosswise by lines of light but porous brush work to regulate the distribution of the deposit, otherwise there would be no control as to what the deposit gradient might be. But the cross lines will be inexpensive fences and will be raised or omitted as necessity suggests, and as the basin currents are to be kept very low in order not to disturb deposits already made their exposure will be nominal.

The "outlet barrier" is a brush and gravel structure which, after having reached the height desirable before operations begin, is thereafter to be added to, foot by foot, as sediment lodges above it, the crest being kept 2 or 3 feet above the accumulations. Were this otherwise, the structure might have a load of 17 feet of water to withstand by the time it reached its full height. This is not the intention, as its upper levels are merely a gravel embankment faced with brush sufficiently to permit a certain flow of water to pass over it, but not after its earlier life to be exposed to flood duty. This depth is intended to be about 3 inches, and is determined by several considerations.

The outlet barrier is provided with four openings, two in each basin compartment, water passing off through a concrete culvert in the lower story and by a weir device above it. The latter is crib work and its bed or escape level is to be raised progressively as the embankment is raised, otherwise sediment would block the exit. This requirement causes the somewhat complicated appearance of the drawing.

Close to the outlet passages will be seen on figure 9 of sheet C two triangular crib structures designated "discharge regulators," of which several sections besides the plan are shown. The regulators also are intended to be built up gradually as sediment accumulates, but are substantial enough not to depend upon that support. They are leakage devices and furnish a large perforated surface for water to escape with as little disturbance as possible, but at discharging orifices low velocities are not practical and nonerosive substances are necessary. The regulators are pyramids of roughly-joined logs supported by walls of cross logs, which brace upon the masonry sides and pillars of a well or cistern, into which the drainage from the basin drops and then passes out through the culvert. The log work is sufficiently open to afford free passage for all the water which is permitted to flow through the chinks of a large number of boards which are arranged to slide in grooves supported by the outer surface of the log work. These flashboards are short planks which can be easily manipulated by one operator, and can be set any desired space apart or may be taken off, all or any number of them, to drain the reservoir as rapidly or slowly as is desired.

The weir device in the barrier is quite similar in principle and mode of operation, and provides additional off-flow surface.

The drawings, figures 9 and 10, are in two halves and illustrate different periods of development. Figure 9, in particular, shows parts of the work with the flashboards taken off, while the other parts of the structure are broken away to better exhibit the construction. The line-shaded surfaces in figure 9 represent the side walls of the masonry well, and the small piers which project above the same are shaded to make them prominent, not to denote section.

Three thousand cubic feet per second is the flow which it appears desirable to accommodate in the settling system, but it is not easy to provide regulation for so large a flow and at the same time avoid velocities higher than appear desirable for effective settling. The length of outlet barrier for each compartment of the basin will not much exceed 1,500 feet of available crest. If the only off-flow were over the barrier it would represent a duty of 2 cubic feet per second per foot of barrier, representing a depth of about 9 inches, or nearly 3 feet average discharge velocity, which

would be objectionable, besides not providing any means of drawing the surface down preparatory to refilling the basin. The discharge regulator is designed to overcome this difficulty by providing a large off-flow section. It promises to meet a requirement and to cover other obstacles which might cause difficulty, but which it is not possible to discuss briefly. The main objection is the expense, which is considerable, as it is proposed to equip the system with four such structures, one opposite each outlet. It may suffice to say that with a provision of this character and extent it would be possible to operate the basin almost entirely by manipulation at the entrance, the escape being automatic, and the emptying process commencing as soon as water at the inlet is shut off. No alteration of the spacing of flashboards would be necessary except when the flow to be handled in the system underwent so material a change as to suggest altering the period of rotation of compartments. By the use of the regulators, when operating at the full capacity of 3,000 second-feet, one compartment of the system could be used indefinitely, leaving the other compartment free for barrier building or repairs. Or it would be possible to shut off one compartment and to permit water to remain absolutely dead six hours, afterwards permitting it to drain off as in the preceding case and still leave time to repeat with the other compartment; or the operation may be made a steady, continuous forward motion so gradual that about seven hours would be required to traverse the basin.

We have been considering conditions applicable to a relatively early period of the works, and the foregoing statements would apply when the outlet barrier had reached level 120 feet, when the capacity between it and elevation 117 feet would represent about 20,810,000 cubic feet for one compartment only, a space which 3,000 cubic feet per second would fill in about one hour and fifty-six minutes. The spacing of the flashboards at the outlets has been taken at one-half inch.

By emptying and filling a basin a fluctuation of water level of about 3 feet has been tacitly understood, regardless of the position of the sediment line. This would correspond to the intended practice, which among other things would be determined by the safety of the partition levee, which it is not desirable to subject to great fluctuations of water level.

The question involved in the discussion of the discharge regulators is one of how much outflow surface should be given to the storage basins, and how best to apply it. With the arrangement indicated in the plans the outflow by weir and towers for one storage compartment would be 1,776 cubic feet per second, that over 3 inches' depth on the barrier 600 cubic feet per second, showing that the artificial outlets would do nearly three-fourths of all the delivery under the conditions assumed.

The cost of the regulators is the main objection. As illustrated in the drawings, an estimate for four pairs of towers and the weirs would be $47,326. By unimportant alterations of their construction, and especially by permissible reduction of the concrete work, their cost could be reduced, without change of the general dimensions, to $41,500, which amount has been adopted in the estimate of costs, being deemed a sufficient allowance to cover the item irrespective of changes which might be made hereafter. The amount of flashboard relief may be excessive, but it is gratifying that in this item of uncertainty opportunity offers to experiment before deciding upon the whole outlay. As one compartment would for a time answer the requirements of even maximum service, one tower could be used to determine the further necessities.

In preparing the estimate of cost of the projected works, effort has been made to consider the subject in various aspects, to anticipate difficulties and to provide for them as well as possible in a problem that involves features not met with in ordinary practice. It was endeavored by field work to minimize the uncertainties, and the estimates have been consistently carried out in conformity with the drawings. But it will be understood that the structures illustrated are not to be regarded as final, and are subject to alteration wherever they can be altered with advantage. The main point is not to have overlooked or omitted necessary works.

The original estimates take up too much space to be submitted, except as an office record, and the amounts here given are summaries from that record. For the purposes of a general report, this information appears sufficient, especially in view of what has just been said.

Project of 1899—Estimate of cost of works.

Division I:		
Barrier No. 1—		
Barrier proper, length 1,100 feet	$90,750.00	
By-pass and all other items for protecting river bed and side slopes	81,181.15	
		$171,931.15
Barrier No. 2—		
Length on crest, 1,000 feet		88,825.00
Division II:		
(No works projected.)		

Division III:			
Flood-overflow barrier			$39,610.00
Daguerre Point cut—total estimated yardage, 522,399 yards:			
	Cubic yards.	Cost.	
Rock	98,507	$26,543.05	
Gravel	311,835	50,946.58	
Earth and soil	112,057	14,915.70	
	522,399	92,405.33	
In extension of cut to river channel, about 110,000 yards, at an allowance of		10,000.00	
		102,405.33	
Inlet wall and protection of bed and sides of cut, estimate, $22,300; allowance, including contingencies		25,000.00	
			127,405.33
Daguerre barrier			46,971.00
SETTLING BASIN.			
Inlet barrier and culverts:			
Embankment from south shore to junction with flood overflow on Pine Island		21,004.50	
Four culverts leading to basin		17,133.60	
			38,138.10
Embankment between basin and river channel—			
Subdivision 1, from flood overflow to Daguerre barrier		38,433.00	
Subdivision 2, from Daguerre barrier to outlet barrier		26,485.00	
			64,918.00
Outlet barrier, including weirs and discharge regulators:			
Embankment		49,770.00	
Four sets of weirs and four pairs of regulating towers; allowance for same, as per modified estimate (see text), original estimate being $47,326		41,500.00	
			91,270.00
Linda Levee:			
Estimated cost of raising same			10,409.00
Partition levee		43,179.00	
Allowance for brush checks, at an approximate cost of $1 per foot		7,000.00	
			50,179.00
Total cost of all projected works on Divisions I and III			729,656.58

Having described the works planned for the upper portion of the river, it may be well to glance at cross sections 5 to 19, shown on sheets 1 to 4, which illustrate Division IV.

The most noticeable feature is the increasing prominence assumed by the central channel, in part a result of scour, in part due to bank formation. This feature is preserved as far as cross section 15, just above which point the channel divides, the apparently principal branch deflecting south, where it in fact becomes a portion of the basin which occupies this part of the river bed. From this on toward Marysville there is, since 1893, no marked alteration of the deposit line to be seen from the surveys made at the low-water period; the bed line oscillates to some extent, but fill and erosion appear to balance. At certain times of flood, when Feather River remains low, there may be less inaction in this channel, as is indicated by soundings taken just after the March flood of 1899, when visible traces of scour were still apparent. The cause of this loss of channel identity appears to be that a portion of the flow, which farther up the river is confined within banks, loses itself in one basin, while a separate river is formed at another (marked "swamp" upon sheet A), drawing its water by spill over from points above and by side connection with the channel forks. At this point the river appears to flow upstream, or nearly so, and near here the river and the levees have been in conflict for a long time. A substantial brush dam, anchored by steel cables (known locally as the Cable Dam, and shown on sheet A), was thrown across the channel to check its activity, still nature asserts herself and continues to send a large proportion of the flow across country by the most direct route to the railroad bridge, still maintaining a notable channel along the route. Below the dam the high-water gradients along this line in 1899, as nearly as there are data to calculate them, were about as follows:

Between sections 15 and 16, 6.5 feet per mile for 3,000 feet; between sections 16 and 17, 5.8 feet per mile for 3,000 feet; between section 17 and the railroad bridge, 2 7 feet per mile for 6,800 feet; but the latter gradient is inaccurate, as the flow rejoins the main channel some distance above the bridge.

This description applies to the spring of 1899. At other times the conditions have been quite different. At one time all along the Browns Valley Levee a river had to be contested with, and the map shows that at that time a cross-country flow took place, running southwest, as evidenced by the broad sweep of sand which will be seen to leave the main channel bank and to make direct for the Linda Levee.

Without following the matter in greater detail, it may be stated that along the paths of each principal channel there is a gradual spill over and loss of carrying capacity as the channel advances, and correspondingly a transfer of waters, when the river is high, from one part to another of the basin out of the natural route.

As regards the surface of the brush lands on Division IV, there is noticeable, as far west as cross section 10, the characteristic failure to build up on the north side. After this a slightly increasing deposit occurs which seldom even locally exceeds 2 feet in depth. In the central and southerly portions of the basin the filling commences somewhat sooner, namely, about section 8. It increases to an average deposit of about 2½ or 3 feet along banks near sections 12 and 13, though somewhat less in the depressions, and then slacks off until, in the vicinity of Marysville, but little fill is noticeable except that shown at portions of the channel bed.

Using the cross sections as the basis for calculations, the total amount of scour at the principal channel since 1893 may be quite closely determined, the estimates being as follows: Between sections 1 and 5, 1,015,700 cubic yards; between sections 5 and 16, 2,200,380 cubic yards. Correspondingly the total deposit from the State Dam to the railroad bridge at Marysville is 14,238,000 cubic yards, approximately, counting fill only. The first of these amounts shows the scour in a channel lying almost entirely within the lines of the proposed settling basin, and which would fill up and disappear. It may be disregarded except as an unfigured increment to the capacity of the basin which was calculated from general surface contours, ignoring all depressions. The second and third amounts measure the work of favorable activities, at least in relationship to their immediate surroundings. All agencies which tend to concentrate flow in well-defined lines are beneficial in so far as they counteract the unsettling influences commented upon in the recital of objectionable conditions. If conditions are but brought to a state of rest, improvement is sure to follow. There can be but little doubt that conditions have improved between Daguerre Point and Marysville. The channel ways have improved, and the gradual formation of so large a body of slickens lands is a marked improvement, always provided that there is assurance that lands once formed will not be again covered up or bodily washed away. But the conditions in the Yuba Basin are not independent of those in the Feather River, at least for some miles below the mouth of the Yuba, and it would be premature to mark improvements final until it has become established that benefits in one locality are not being counterbalanced in the other. Otherwise the apparently improved order of things can only be transitory; if the river plane has lowered it will surely rise again, leaving conditions in worse shape than they were before supposed betterments claimed notice.

Information is lacking as to the condition in Feather River, but there appears reason to suspect that a blockage may exist in that river at a point not so far below Marysville as not to affect seriously the conditions there. The circumstances are the following: An attempt was made to determine the high-water flow during the March flood of 1899. Float measurements were taken at the two bridges at Marysville. Also below the Parks Bar Bridge, near Timbuctoo, high-water marks were noted carefully at the time, and from these an independent estimate was afterwards made of the flood discharge at that point. The two measurements bear each other out even more closely than was anticipated. Making due allowances for water which did not pass the gauge section, owing to side escape, there is reason to assume that the Yuba River, at Marysville, was discharging less than 70,000 cubic feet per second, 60,000 second-feet being a more probable figure. The flood was only peculiar in so far as complications with Feather River were lacking to an unusual degree, and, perhaps, because it was a rainstorm without much snow in the mountains before the storm. For the Yuba it brought about a sharp, pronounced flood wave which reached a rapid culmination, but the flood was decidedly one of ordinary magnitude. Yet on March 25 the D Street Bridge recorded 18 feet 5 inches, while the highest record during any previous year was 18 feet 11 inches, on December 26, 1892, a difference of 6 inches, or 0.5 foot. The differences at various points of the river along the Browns Valley Levee are interesting enough to record. At section 15, in the basin below the Cable Dam, the 1899 surface was 0.1 foot higher; at section 16, above the Cable Dam, both surfaces agree; but above this point the 1892 marks are the higher by the following amounts: Section 13, 0.1 foot; section 12, 0.6 foot; section 11, 1 foot; section 10, 1.8 feet; section 9, 1.1 feet.

There would be good reason to account for obstruction in Feather River: in part, perhaps, owing to the improved condition of the mouth of Yuba River, but principally because all the changes which have been noted as beneficial in the Yuba River sense have undoubtedly aided to produce conditions favorable for transporting heavier material and more of it, if supplied to the river below. This remark applies all the way from Marysville to the Narrows and perhaps beyond the Narrows.

The Yuba River may be regarded either as a river or as an immense impounding space. Hitherto it has been principally the latter, and, viewed merely as a receptacle, it has met the requirements surprisingly well, for all the conditions which have been unfavorably criticised then appear in different light. However, it is quite probable that a different phase is developing. With less duty placed upon it the river has, so to speak, been putting to rights its own affairs, and unless prevented from doing so will find relief, be it in one direction or in another.

Some of the brush lands, under the improved conditions, are becoming valuable enough to cultivate, but unfortunately are being denuded of their brush covering by a short-sighted practice likely to lead to much trouble.

Work upon Division IV should not be commenced unless under assurances that lands would not be cleared in a manner likely to conflict with work for the improvement of the river, nor until the conditions in Feather River have been ascertained.

The plan of treatment appears to be a very natural one. Upon sheet A will be noticed two lines marked, respectively, "north line of training wall" and "south line of training wall," and their position appears also upon cross sections 1 to 19. The designation "training wall" is not quite appropriate, for the lines are employed merely to mark position, not to indicate actual structures proposed or even contemplated. They are imaginary boundaries, but the unfavorable conditions of Division IV would be overcome if it were practicable to confine the river within them.

The cross sections show that the lines follow elevated ground as far as it is practicable to make them do so, and that they include the central river channel, or at least low ground between them. Nature is working along these lines and has been doing so. All that is called for in treatment would be to assist it to hold them, the idea being to prevent dispersion, to concentrate the flow gradually, and to foster bank formation. The work would be governed entirely by the conditions at the time existing, and these would alter continually. Only a general scheme of operations can be mapped out for such work in advance, a detailed estimate being, of course, out of the question. The work would resolve itself into a multitude of small works, some of them too trifling to require any plans, and would be of the character best covered by the daily labor of an intelligently directed work force, but not necessarily one kept always organized.

The operations would consist in clearing lines of brush to facilitate flow, in blocking side channels gradually to obstruct it, in building brush work for spurs to direct current, or for silt arresters to build up land, the work wherever possible to be disposed at the training walls or near by, but not following any prescribed line. The lines of training wall, so called, would actually be property lines, inside of which liberty should exist to conduct work with perfect freedom.

There might be some dredging or snagging to remove obstacles in the path of flow, but seeing that the drainage from the settling basin is intended to follow a southerly route, operations during the dry season of the year would not be interfered with by water.

The outcome, perhaps attainable at the end of several years, would be a well-defined river channel of good capacity, bordered by lands which would overflow and form part of the river during flood, and back of these there would be private lands in process of reclamation, but perhaps still subject to periodical inundation. In brief, the idea is to cause the river to make deposits where desirable, but otherwise to prevent them. Such work is very desirable and should not be needlessly deferred, and it is therefore suggested that an item to cover the cost, for instance, $50,000, should be added to the estimate for improving Yuba River.

This outlay would be one from which a compensating return might soon be realized, for there is an area of about 4,000 acres included between the south training wall and Linda Levee, the outlet barrier of the settling basin, and cross section 16 as a westerly limit. A deposit of 1 foot, could it but be equally distributed over the surface, would represent about 6,500,000 yards, but if a plane be applied at the base of the outlet barrier, starting at elevation 110 feet and descending to westward at the rate of 1 foot per thousand, it would include below its surface a storage of about 26,000,000 yards, and it would be only a matter of making very trifling additions to the height of Linda Levee to add 4 additional feet over the area, or 26,000,000 cubic yards more, making 52,000,000 yards in all. There should be no mechanical difficulty in the way of making this storage, or a portion of it, available as an extension of the settling basin, for even at the higher level the surface would lie 11 feet below that contemplated as a final storage surface in the basin. And such a modification of the plans could only benefit the lands, besides tending to

reduce the estimated outlay for the basin. These figures speak well for the prospective amount of storage for fine sediment, but this storage can not be made available except after partial execution of the work of Division IV, thus preventing sediment deposited in the low basins from being washed away by overflow from the river during its high stages. Indeed, this method of obtaining storage would be cheaper than the settling basins described, and in the construction of the works this cheaper and perhaps more desirable method of obtaining storage would probably be adopted.

The estimated amount of storage above barriers Nos. 1 and 2 is 33,176,000 cubic yards if the estimate be based upon an assumed gradient of 15 feet per mile, supposed to start from barrier No. 2 1 foot below its crest level, or at elevation 245 feet. This plane reaches an elevation of 315 feet at the Narrows, at which point it is about 25 feet above the general surface of the river deposit. Beyond here and below the same top plane extended up into the canyon it is roughly estimated that there would be about 3,304,000 cubic yards. For all working purposes it will therefore be sufficiently exact to assume the probable storage for coarse material at 36,480,000 cubic yards, and if we charge up to its account the combined cost of the two barriers, viz, $260,756.15, the cost per unit stored would be a trifle less than 0.7 cent. In contrast with this, if we assumed that conditions would reproduce themselves in a new surface 40 feet above the present river bed, the estimate to the Narrows would be slightly greater, namely, 35,830,000 cubic yards, to which it would be correct to add 8,933,000 yards; that is, the storage of a dam 40 feet high at the Narrows upon a 15 feet gradient, making a total of 44,763,000 cubic yards. Upon this yardage basis the cost per unit stored would be 0.58 cent.

The cost per cubic yard of storage for fine sediment would be 1.76 cents if we debit its account with all the items of cost associated with the storage basin, namely, $254,914.10, and assume the capacity of that basin to be 14,469,000 yards. But this rate can be materially reduced, beyond doubt, for the reasons already explained.

For a comparison of these figures with the cost of storage by means of a dam at the Narrows attention is respectfully directed to the earlier part of this report.

We have an estimate of the amount of deposit from the Narrows to the State Dam during nineteen years, 33,637,000 cubic yards; also an estimate of the fill from the State Dam to Marysville for six years, 14,238,000 cubic yards, but no figures obtained by direct observation for the deposit upon the whole river area for any period at all. But it will hardly be questioned that the deposit over the upper portion of the river must have been relatively less during the last six years than it was for the earlier thirteen. The last six years have been relatively dry years, without notable freshets. Hydraulic mining has been under control since 1893, whereas the first thirteen years cover at least five years when hydraulic mining was at its highest activity. Finally, the sweeping of the upper canyons was pretty well accomplished prior to 1893, as there are reports from actual examination to prove. It would therefore appear that we are safely within the facts if we take the sum of the two averages and accept it as an expression of the annual rate of accumulation since 1893. The first average is 1,770,000 cubic yards, in round numbers; the second, 2,373,000, and the sum of both, 4,143,000 cubic yards. This figure may be used as an indication of the length of time that the storage provided under the project of 1899 would last if there should be no increase of the annual requirement, and under present conditions this requirement should be a decreasing quantity.

Comparing the foregoing figures with the storage estimates for the higher levels of the Narrows Dam the showing is favorable to the project of 1899, considering only the totals and rates, quite independent of the security afforded by the two systems. The 1899 project possesses superiority also in that it provides for future requirements if need should arise, while the Narrows Dam gave no such outlook. Should barriers 1 and 2 be built and meet expectations, additional barriers can be built as required, each being a practical repetition of barrier No. 2, which may serve as a type for all of them. In fact, these barriers differ very little from the plan of storage proposed in the débris report of 1880 (House Ex. Doc. No. 69, Forty-sixth Congress, second session), except that they aim to provide the elements of safety less by reason of the mass of rock to be used in the structure than by a greater distance between barriers and by greater toe security. But for this modification there is a good explanation. Rock which would furnish large dimension stone had been represented as an abundant material, whereas the examinations made in 1899 failed to show this to be so. Wherever sought for rock was developed, but the harder material always appeared to be in kidneys or surface blow-outs, and the formation was never shown to be of a uniform character. Large dimension stone was therefore not made a feature in any design.

The estimates for the 1899 project are sufficient to cover the storage requirements for several years, perhaps ten, perhaps more. Having indicated the practical identity of the methods proposed for storing coarse material, the estimates made in former years may be accepted as safe figures for the cost as well as for the amounts of additional storage, with the understanding that the figures refer to coarse detritus.

With this system of storage by low barriers, which do not require bed-rock foundations, the objectionable features of the Narrows Canyon would disappear, and the gorge, considering its superior rock supply and favorably situated bluffs, would possess advantages which should not be lost sight of.

It yet remains to show the most suitable manner of disposing of coarse material. May it not, after all, be cheaper and more secure, at least in particular cases, to hold this character of material in the principal tributaries, where the watersheds are, comparatively speaking, small, rather than in the main rivers, where the flood exposure is considerable? This question has never as yet been carefully looked into.

The subject under examination is so broad that it may be wise not to attempt to look too far ahead. For, in attempting to cover more ground than is necessary, there exists danger of inaccuracy as well as in covering too little at the risk of overlooking some important detail. Things are liable to develop in a different manner from that assumed. As an instance of this there is the settling basin for storing fine material. In order to make an estimate it was necessary to assume boundaries somewhere and to select a probable level for the storage surface, and accordingly the estimate figures apply to that level, whereas the actual developments would seek the cheaper lines offered by the execution of the works of Division IV. This handicap has been a constant one. In a scheme which is essentially one of gradual developments, which aims to secure economies through the assistance of natural causes judiciously directed, though the facts were recognized, it has not been found easy to give expression to them in casting up figures.

As regards the barriers for storing coarse gravel, barrier No. 1 with its by-pass is an essential feature of the project of 1899, so styled. Yet, in view of the very considerable cost of the by-pass and its accessories, almost equaling the cost of the barrier part of the work, a serious question may be raised whether it might not be judicious to eliminate the by-pass feature and put more money into the dam. But in that case the principal motive for selecting this particular site falls away, and what is now styled barrier No. 2 should form the lower structure of the system. It is not open to question that more storage could be obtained for less money under this change of plan. Still, the personal bias of the writer leans to the present plan, believing it, though more costly, to be the more secure, and, in the long run, more liable to give satisfaction. The lowest barrier of the system, wherever it be located, has to make secure the ones above it, and it is a wide distinction whether over this important structure a 9 foot depth of water is to pass or only one of 3½ feet.

Division II has had no works planned for it, but has not been altogether overlooked. As barrier No. 1 is not expected to have any water flow over it except occasionally, and then only during brief periods, it would be practicable to foster growths of tress upon the whole division, clothing with vegetation that which is now a waste of shifting sands, but reserving a width of about 1,500 feet to serve as an unobstructed waterway along the north shore. This would furnish an additional and inexpensive method of affording toe protection to barrier No. 1.

The facilities for conducting operations are exceptionally good, the low-water season lasting usually eight months or more, and affording absolute freedom of action even in the river bed, while the parts of the work not in the river would be subject only to interruptions common to out-door work. In this district the rainfall is light, snow and frost are absent, and cheap power is assured, for the line of the Yuba Electric Power Company parallels the works at a distance of about 1 mile, and systems of ditches giving fair pressure exist on each side of the river, while fuel is cheap and abundant and everywhere at hand. But the most economical of all power sources might be an independent air-compressing plant.

Concerning the probable efficiency of the storage works, the successful operation of the settling basin involves a question of transporting solids by water. The security of the upper-river barriers implies that they shall be made to hold back cobbles, gravel, and coarser sand, but not any considerable amount of fine matter. The suspensory matter and silt and finer sands will probably not cause any difficulty in the basins, but there may perhaps exist an intermediate grade too fine to store above, too coarse not to cause difficulty below. It may be appropriate to state that should this prove to be the case the subject has not been overlooked, and is provided for, but it is expected that a classification into two grades may suffice.

In concluding this report it may be permissible to enumerate the advantages which may be claimed for the project of 1899:

1. It is a project of slow development; it does not expend any considerable amount of money in advance of results; it affords time to acquire experience as work progresses, and in no instance are structures so located as not to make alterations practicable. It husbands the interest account.

2. It calls for no works of a daring or experimental type. There are few portions which, if constructed or partially completed, would not produce benefit and be separately operative, even if afterwards neglected, and it does not so store material that the conditions would be worse, should the structures be destroyed, than if they had never existed.

3. It is remedial and beneficial, creates lands but damages none, and aims to bring about order where there is now no order.

Very respectfully,

HUBERT VISCHER,
Assistant Engineer.

The CALIFORNIA DÉBRIS COMMISSION,
San Francisco, Cal.

ACT OF CONGRESS, APPROVED MARCH 1, 1893, CREATING THE CALIFORNIA DÉBRIS COMMISSION.

AN ACT to create the California Débris Commission and regulate hydraulic mining in the State of California.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That a commission is hereby created, to be known as the California Débris Commission, consisting of three members. The President of the United States shall, by and with the advice and consent of the Senate, appoint the commission from officers of the Corps of Engineers, United States Army. Vacancies occurring therein shall be filled in like manner. It shall have the authority, and exercise the powers hereinafter set forth, under the supervision of the Chief of Engineers and direction of the Secretary of War.

SEC. 2. That said commission shall organize within thirty days after its appointment by the selection of such officers as may be required in the performance of its duties, the same to be selected from the members thereof. The members of said commission shall receive no greater compensation than is now allowed by law to each, respectively, as an officer of said Corps of Engineers. It shall also adopt rules and regulations, not inconsistent with law, to govern its deliberations and prescribe the method of procedure under the provisions of this act.

SEC. 3. That the jurisdiction of said commission, in so far as the same affects mining carried on by the hydraulic process, shall extend to all such mining in the territory drained by the Sacramento and San Joaquin river systems in the State of California. Hydraulic mining, as defined in section eight hereof, directly or indirectly injuring the navigability of said river systems, carried on in said territory other than as permitted under the provisions of this act is hereby prohibited and declared unlawful.

SEC. 4. That it shall be the duty of said commission to mature and adopt such plan or plans, from examinations and surveys already made and from such additional examinations and surveys as it may deem necessary, as will improve the navigability of all the rivers comprising said systems, deepen their channels, and protect their banks. Such plan or plans shall be matured with a view of making the same effective as against the encroachment of and damage from débris resulting from mining operations, natural erosion, or other causes, with a view of restoring, as near as practicable and the necessities of commerce and navigation demand, the navigability of said rivers to the condition existing in eighteen hundred and sixty, and permitting mining by the hydraulic process, as the term is understood in said State, to be carried on, provided the same can be accomplished, without injury to the navigability of said rivers or the lands adjacent thereto.

SEC. 5 That it shall further examine, survey, and determine the utility and practicability, for the purposes hereinafter indicated, of storage sites in the tributaries of said rivers and in the respective branches of said tributaries, or in the plains, basins, sloughs, and tule and swamp lands adjacent to or along the course of said rivers, for the storage of débris or water or as settling reservoirs, with the object of using the same by either or all of these methods to aid in the improvement and protection of said navigable rivers by preventing deposits therein of débris resulting from mining operations, natural erosion, or other causes, or for affording relief thereto in flood time and providing sufficient water to maintain scouring force therein in the summer season; and in connection therewith to investigate such hydraulic and other mines as are now or may have been worked by methods intended to restrain the débris and material moved in operating such mines by impounding dams, settling reservoirs, or otherwise, and in general to make such study of and researches in the hydraulic mining industry as science, experience, and engineering skill may suggest as practicable and useful in devising a method or methods whereby such mining may be carried on as aforesaid.

SEC. 6. That the said commission shall from time to time note the conditions of the navigable channels of said river systems, by cross-section surveys or otherwise, in order to ascertain the effect therein of such hydraulic mining operations as may be permitted by its orders and such as is caused by erosion, natural or otherwise.

SEC. 7. That said commission shall submit to the Chief of Engineers, for the infor-

mation of the Secretary of War, on or before the fifteenth day of November of each year, a report of its labors and transactions, with plans for the construction, completion, and preservation of the public works outlined in this act, together with estimates of the cost thereof, stating what amounts can be profitably expended thereon each year. The Secretary of War shall thereupon submit same to Congress on or before the meeting thereof.

SEC. 8. That for the purposes of this act "hydraulic mining" and "mining by the hydraulic process" are hereby declared to have the meaning and application given to said terms in said State.

SEC. 9. That the individual proprietor or proprietors, or in case of a corporation its manager or agent appointed for that purpose, owning mining ground in the territory in the State of California mentioned in section three hereof, which it is desired to work by the hydraulic process, must file with said commission a verified petition, setting forth such facts as will comply with law and the rules prescribed by said commission.

SEC. 10. That said petition shall be accompanied by an instrument duly executed and acknowledged, as required by the law of the said State, whereby the owner or owners of such mine or mines surrender to the United States the right and privilege to regulate by law, as provided in this act, or any law that may hereafter be enacted, or by such rules and regulations as may be prescribed by virtue thereof, the manner and method in which the débris resulting from the working of said mine or mines shall be restrained, and what amount shall be produced therefrom; it being understood that the surrender aforesaid shall not be construed as in any way affecting the right of such owner or owners to operate said mine or mines by any other process or method now in use in said State: *Provided*, That they shall not interfere with the navigability of the aforesaid rivers.

SEC. 11. That the owners of several mining claims situated so as to require a common dumping ground or dam or other restraining works for the débris issuing therefrom in one or more sites may file a joint petition setting forth such facts in addition to the requirements of section nine hereof; and where the owner of a hydraulic mine or owners of several such mines have and use common dumping sites for impounding débris or as settling reservoirs, which sites are located below the mine of an applicant not entitled to use same, such fact shall also be stated in said petition. Thereupon the same proceedings shall be had as provided for herein.

SEC. 12. A notice specifying briefly the contents of said petition and fixing a time previous to which all proofs are to be submitted shall be published by said commission in some newspaper or newspapers of general circulation in the communities interested in the matter set forth therein. If published in a daily paper, such publication shall continue for at least ten days: if in a weekly paper, in at least three issues of the same. Pending publication thereof said commission, or a committee thereof, shall examine the mine and premises described in such petition. On or before the time so fixed all parties interested, either as petitioners or contestants, whether miners or agriculturists, may file affidavits, plans, and maps in support of their respective claims. Further hearings, upon notice to all parties of record, may be granted by the commission when necessary.

SEC. 13. That in case a majority of the members of said commission, within thirty days after the time so fixed, concur in a decision in favor of the petitioner or petitioners, the said commission shall thereupon make an order directing the methods and specifying in detail the manner in which operations shall proceed in such mine or mines; what restraining or impounding works, if facilities therefor can be found, shall be built and maintained; how and of what material; where to be located; and in general set forth such further requirements and safeguards as will protect the public interests and prevent injury to the said navigable rivers, and the lands adjacent thereto, with such further conditions and limitations as will observe all the provisions of this act in relation to the working thereof and the payment of taxes on the gross proceeds of the same: *Provided*, That all expense incurred in complying with said order shall be borne by the owner or owners of such mine or mines.

SEC. 14. That such petitioner or petitioners must within a reasonable time present plans and specifications of all works required to be built in pursuance of said order for examination, correction, and approval by said commission; and thereupon work may immediately commence thereon under the supervision of said commission or representative thereof attached thereto from said Corps of Engineers, who shall inspect same from time to time. Upon completion thereof, if found in every respect to meet the requirements of the said order and said approved plans and specifications, permission shall thereupon be granted to the owner or owners of such mine or mines to commence mining operations, subject to the conditions of said order and the provisions of this act.

SEC. 15. That no permission granted to a mine owner or owners under this act shall take effect, so far as regards the working of a mine, until all impounding dams or

other restraining works, if any are prescribed by the order granting such permission, have been completed and until the impounding dams or other restraining works or settling reservoirs provided by said commission have reached such a stage as, in the opinion of said commission, it is safe to use the same: *Provided, however,* That if said commission shall be of the opinion that the restraining and other works already constructed at the mine or mines shall be sufficient to protect the navigable rivers of said systems and the work of said commission, then the owner or owners of such mine or mines may be permitted to commence operations.

SEC. 16. That in case the joint petition referred to in section eleven hereof is granted, the commission shall fix the respective amounts to be paid by each owner of such mines toward providing and building necessary impounding dams or other restraining works. In the event of a petition being filed after the entry of such order, or in case the impounding dam or dams or other restraining works have already been constructed and accepted by said commission, the commission shall fix such amount as may be reasonable for the privilege of dumping therein, which amount shall be divided between the original owners of such impounding dams or other restraining works in proportion to the amount respectively paid by each party owning same. The expense of maintaining and protecting such joint dam or works shall be divided among mine owners using the same in such proportion as the commission shall determine. In all cases where it is practicable, restraining and impounding works are to be provided, constructed, and maintained by mine-owners near or below the mine or mines before reaching the main tributaries of said navigable waters.

SEC. 17. That at no time shall any more débris be permitted to be washed away from any hydraulic mine or mines situated on the tributaries of said rivers and the respective branches of each, worked under the provisions of this act, than can be impounded within the restraining works erected.

SEC. 18. That the said commission may at any time, when the condition of the navigable rivers or when the capacities of all impounding and settling facilities erected by mine-owners or such as may be provided by Government authority require same, modify the order granting the privilege to mine by the hydraulic mining process so as to reduce amount thereof to meet the capacities of the facilities then in use, or if actually required in order to protect the navigable rivers from damage, may revoke same until the further notice of the commission.

SEC. 19. That an intentional violation on the part of a mine owner or owners, company, or corporation, or the agents or employees of either, of the conditions of the order granted pursuant to section thirteen, or such modifications thereof as may have been made by said commission, shall work a forfeiture of the privileges thereby conferred, and upon notice being served by the order of said commission upon such owner or owners, company, or corporation, or agent in charge, work shall immediately cease. Said commission shall take necessary steps to enforce its orders in case of the failure, neglect, or refusal of such owner or owners, company, or corporation, or agents thereof, to comply therewith, or in the event of any person or persons, company, or corporation working by said process in said territory contrary to law.

SEC. 20. That said commission, or a committee therefrom, or officer of said corps assigned to duty under its orders, shall, whenever deemed necessary, visit said territory and all mines operating under the provisions of this act. A report of such examination shall be placed on file.

SEC. 21. That the said commission is hereby granted the right to use any of the public lands of the United States, or any rock, stone, timber, trees, brush, or material thereon or therein, for any of the purposes of this act; and the Secretary of the Interior is hereby authoized and requested, after a notice has been filed with the Commissioner of the General Land Office by said commission, setting forth what public lands are required by it under the authority of this section, that such land or lands shall be withdrawn from sale and entry under the laws of the United States.

SEC. 22. That any person or persons who wilfully or maliciously injure, damage, or destroy, or attempt to injure, damage, or destroy, any dam or other work erected under the provisions of this act for restraining, impounding, or settling purposes, or for use in connection therewith, shall be guilty of a misdemeanor, and upon conviction thereof shall be fined not to exceed the sum of five thousand dollars or be imprisoned not to exceed five years, or by both such fine and imprisonment, in the discretion of the court. And any person or persons, company or corporation, their agents or employees, who shall mine by the hydraulic process directly or indirectly injuring the navigable waters of the United States, in violation of the provisions of this act shall be guilty of a misdemeanor, and upon conviction thereof shall be punished by a fine not exceeding five thousand dollars, or by imprisonment not exceeding one year, or by both such fine and imprisonment, in the discretion of the court: *Provided,* That this section shall take effect on the first day of May, eighteen hundred and ninety-three.

SEC. 23. That upon the construction by the said commission of dams or other works for the detention of débris from hydraulic mines and the issuing of the order provided for by this act to any individual, company, or corporation to work any mine or mines by hydraulic process, the individual, company or corporation operating thereunder working any mine or mines by hydraulic process, the débris from which flows into or is in whole or in part restrained by such dams or other works erected by said commission, shall pay a tax of three per centum on the gross proceeds of his, their, or its mine so worked; which tax of three per centum shall be ascertained and paid in accordance with regulations to be adopted by the Secretary of the Treasury, and the Treasurer of the United States is hereby authorized to receive the same. All sums of money paid into the Treasury under this section shall be set apart and credited to a fund to be known as the "débris fund," and shall be expended by said commission under the supervision of the Chief of Engineers and direction of the Secretary of War, in addition to the appropriations made by law in the construction and maintenance of such restraining works and settling reservoirs as may be proper and necessary: *Provided*, That said commission is hereby authorized to receive and pay into the Treasury from the owner or owners of mines worked by the hydraulic process, to whom permission may have been granted so to work under the provisions hereof, such money advances as may be offered to aid in the construction of such impounding dams or other restraining works, or settling reservoirs, or sites therefor, as may be deemed necessary by said commission to protect the navigable channels of said river systems, on condition that all moneys so advanced shall be refunded as the said tax is paid into the said débris fund: *And provided further*, That in no event shall the Government of the United States be held liable to refund same except as directed by this section.

SEC. 24. That for the purpose of securing harmony of action and economy in expenditures in the work to be done by the United States and the State of California, respectively, the former in its plans for the improvement and protection of the navigable streams and to prevent the depositing of mining débris or other materials within the same, and the latter in its plans authorized by law for the reclamation, drainage, and protection of its lands, or relating to the working of hydraulic mines, the said commission is empowered to consult thereon with a commission of engineers of said State, if authorized by said State for said purpose, the result of such conference to be reported to the Chief of Engineers of the United States Army, and if by him approved shall be followed by said commission.

SEC. 25. That said commission, in order that such material as is now or may hereafter be lodged in the tributaries of the Sacramento and San Joaquin river systems, resulting from mining operations, natural erosion, or other causes, shall be prevented from injuring the said navigable rivers or such of the tributaries of either as may be navigable and the land adjacent thereto, is hereby directed and empowered, when appropriations are made therefor by law, or sufficient money is deposited for that purpose in said débris fund, to build at such points above the head of navigation in said rivers and on the main tributaries thereof, or branches of such tributaries, or at any place adjacent to the same, which in the judgment of said commission, will effect said object (the same to be of such material as will insure safety and permanency), such restraining or impounding dams and settling reservoirs, with such canals, locks, or other works adapted and required to complete same. The recommendations contained in Executive Document Numbered Two hundred and sixty-seven, Fifty-first Congress, second session, and Executive Document Numbered Ninety-eight, Forty-seventh Congress, first session, as far as they refer to impounding dams, or other restraining works, are hereby adopted, and the same are directed to be made the basis of operations. The sum of fifteen thousand dollars is hereby appropriated, from moneys in the Treasury not otherwise appropriated, to be immediately available to defray the expenses of said commission.

Approved, March 1, 1893.

ACT OF THE LEGISLATURE OF CALIFORNIA, APPROVED MARCH 24, 1893.

AN ACT to provide for the appointment, duties, and compensation of a débris commissioner, and to make an appropriation to be expended under his direction in the discharge of his duties as such commissioner.

The people of the State of California, represented in senate and assembly, do enact as follows:

SECTION 1. The governor of the State of California shall, on or before the first day of January, eighteen hundred and ninety-four, appoint a competent civil engineer for a period of four years only, to be known as and called the débris commissioner.

SEC. 2. Said commissioner shall, during the time he shall be actually employed in the discharge of his official duties, receive a compensation of three hundred dollars

per month and his necessary traveling expenses, to be allowed by the State board of examiners.

SEC. 3. Whenever any board of engineers of the United States Government shall have been appointed, with power to adopt plans and specifications for the construction of works for the impounding of mining débris, it shall be the duty of said débris commissioner to consult and advise with such board of engineers of the United States Government, and to examine and pass upon the merits of such works, and said debris commissioner shall determine whether or not such works are calculated to and sufficient to protect the navigable waters of the State, and to keep a record of such determinations.

SEC. 4. There is hereby appropriated, out of the general fund of the treasury of this State not otherwise appropriated, the sum of two hundred and fifty thousand dollars, no warrant against said sum to be drawn or paid until the United States Government shall have appropriated at least an equal amount, to be used in the construction of works for the restraining or impounding of mining débris in California, said moneys to be paid only upon orders drawn by the controller, upon the written request of the said débris commissioner, and to be drawn only for the payment of not more than one-half of the cost of the construction of any such works for restraining and impounding mining débris as shall have been approved by him and duly adopted and recommended by engineers of the United States Government appointed for that purpose.

SEC. 5. The term of office of said débris commissioner shall be four years from the date of his appointment. He shall take the same oath of office as is provided by law for other State officers, and before entering upon the discharge of his duties shall give bond with sufficient sureties, to be approved by the governor of the State, in the sum of fifty thousand dollars, for the faithful discharge of his duties as such officer.

SEC. 6. The said débris commissioner shall have the power to appoint a secretary, at a monthly salary to be fixed by said commissioner, not exceeding one hundred and twenty five dollars per month; said secretary to hold office at the pleasure of the said commissioner: *Provided, however*, That no secretary shall be appointed until said débris commissioner shall enter upon the actual discharge of his duties.

SEC. 7. All expenditures authorized by the provisions of this act shall be subject to the approval of the State board of examiners; and the State controller is hereby authorized to draw his warrant for all expenditures not in excess of the appropriation herein provided for, so approved by the State board of examiners, and the State treasurer is hereby directed to pay the same.

EXTRACT FROM RIVER AND HARBOR ACT OF CONGRESS OF JUNE 3, 1896.

For the construction of restraining barriers for the protection of the Sacramento and Feather rivers in California, two hundred and fifty thousand dollars; such restraining barriers to be constructed under the direction of the Secretary of War in accordance with the recommendations of the California Débris Commission, pursuant to the provisions of, and for the purposes set forth in, section twenty-five of the Act of the Congress of the United States, entitled "An Act to create the California Débris Commission and regulate hydraulic mining in the State of California," approved March first, eighteen hundred and ninety-three: *Provided*, That the Treasurer of the United States be, and he is hereby, authorized to receive from the State of California, through the Débris Commission of said State, or other officer thereunto duly authorized, any and all sums of money that have been, or may hereafter be, appropriated by said State for the purposes herein set forth. And said sums when so received are hereby appropriated for the purposes above named, to be expended in the manner above provided.

ACT OF THE LEGISLATURE OF CALIFORNIA, APPROVED MARCH 17, 1897.

AN ACT to amend an Act entitled "An Act to provide for the appointment, duties and compensation of a Débris Commissioner, and to make an appropriation to be expended under his directions in the discharge of his duties as such commissioner," approved March 24, 1893.

The people of the State of California, represented in senate and assembly, do enact as follows:

SECTION 1. Section one of the Act entitled "An Act to provide for the appointment, duties, and compensation of a Débris Commissioner, and to make an appropriation to be expended under his directions in the discharge of his duties as such commissioner," approved March twenty-fourth, one thousand eight hundred and ninety-three, is hereby amended so as to read as follows:

SEC. 1. The Governor of the State of California shall, on or before the first day of January, one thousand eight hundred and ninety-eight, appoint a competent civil

engineer for a period of four years only, to be known as and called the Débris Commissioner; *Provided, however,* That the Débris Commissioner heretofore appointed under the Act entitled "An Act to provide for the appointment, duties and compensation of a Débris Commissioner, and to make an appropriation to be expended under his directions in the discharge of his duties as such commissioner," approved March twenty-fourth, eighteen hundred and ninety-three, shall continue to perform the duties, and receive the compensation of that office, subject to the provisions of this Act, until the expiration of the term for which he was appointed and until the appointment and qualification of the Débris Commissioner provided for by this act.

SEC. 2. Section two of said Act is hereby amended so as to read as follows:

Section. 2. Said commissioner shall receive a compensation of ten dollars per day while actually engaged in the discharge of his duties, and his necessary traveling expenses, to be allowed by the State Board of Examiners.

SEC. 3. Section three of said Act is hereby amended so as to read as follows:

Section 3. It shall be the duty of the said Débris Commissioner to consult and advise with the members of the corps of engineers of the United States Army comprising the California Débris Commission (created by Act of Congress approved March first, eighteen hundred and ninety-three), in relation to the construction of works for the restraining and impounding of débris resulting from mining operations, natural erosion, or other causes; and it shall be his duty to examine such works, and to report the result of such examination to the State Board of Examiners. Said Débris Commissioner is further authorized and directed to consult and advise with said "California Débris Commission" in relation to any and all plans and specifications that may have been, or may hereafter be prepared or adopted by said "California Débris Commission" for the construction of such restraining, or impounding works, and said Débris Commissioner shall submit a copy of all such plans and specifications to the State Board of Examiners for their examination and consideration, together with his approval or disapproval thereof, or other recommendation with reference thereto.

The State Board of Examiners shall thereupon proceed to examine and consider the plans and specifications thus submitted to them, and in that behalf may require the attendance, counsel, and advice of said Débris Commissioner during their examination and consideration thereof. The State Board of Examiners shall keep a record of their deliberations and shall either approve or disapprove said plans and specifications, which approval or disapproval may be by a majority vote of said board; *Provided,* That no plans and specifications involving an expenditure on the part of the State of California of a sum greater than the appropriation herein made shall be approved.

If said plans and specifications be approved by the State Board of Examiners, the said Débris Commissioner shall thereupon report such action to said "California Débris Commission."

Whenever said "California Débris Commission" or the government of the United States shall have entered into any contract for the construction of works for the purposes described in this Act, in pursuance of plans and specifications that have been theretofore approved by the State Board of Examiners as in this Act provided, it shall then be the duty of the Débris Commissioner to carefully inspect such works during the process of their construction and to keep a record of the result of such inspection and to report the same monthly to the State Board of Examiners. Said Débris Commissioner shall also from time to time, during the process of the construction of such works, when requested so to do by the said "California Débris Commission," draw his warrants upon the State Controller in favor of such person or persons as may be designated by said "California Débris Commission" for such amounts as shall equal one half of the cost of the construction of said works; and said Débris Commissioner shall, in like manner, and when requested so to do by said "California Débris Commission," draw his warrant upon the State Controller for an amount equal to one half the purchase price of any site or sites necessary for the construction of said works; *Provided,* That the purchase of such site or sites shall have been first approved by the State Board of Examiners; *And provided further,* That no warrant shall be drawn in excess of the amount appropriated by this act.

SEC. 4. Section four of said Act is hereby amended so as to read as follows:

Section 4. There is hereby appropriated out of the general fund of the treasury of this State not otherwise appropriated, the sum of two hundred and fifty thousand dollars, to be used in the construction of works for the restraining and impounding of débris resulting from mining operations, natural erosion, or other causes, and for the purchase of sites therefor. The appropriation made by this section is intended as a reappropriation of the sum of two hundred and fifty thousand dollars appropriated by the Act Entitled "An Act to provide for the appointment, duties, and compensation of a Débris Commissioner, and to make an appropriation to be expended under his directions in the discharge of his duties as such commissioner," approved March twenty-fourth, eighteen hundred and ninety-three, and it is expressly intended and provided by this Act that the State of California shall, in no

event, incur any liability hereunder beyond the amount of the appropriation herein made, and no contractor, claimant, or person shall acquire any right or obligation against the State of California beyond said sum so appropriated and set apart for the purposes hereinabove set forth, and it is expressly declared that any claim or demand against the State of California in excess of said appropriation shall be invalid and void. Said moneys shall be paid only upon orders drawn by the State Controller upon the written request of said Débris Commissioner, as in the Act provided.

SEC. 5. Section seven of said Act is hereby amended so as to read as follows:

Section 7. All expenditures authorized by the provisions of this Act shall be subject to the approval of the State Board of Examiners, and the State Controller is hereby authorized to draw his warrant for all expenditures not in excess of the appropriation herein provided for so approved by the State Board of Examiners, and the State Treasurer is hereby directed to pay the same.

SEC. 6. This Act shall take effect immediately.

SEC. 7. This Act shall take effect immediately.

Approved, March 17, 1897.

EXTRACT FROM SUNDRY CIVIL ACT OF CONGRESS, APPROVED JULY 1, 1898.

For the purpose of carrying out the following provision of the river and harbor Act of eighteen hundred and ninety-six: "For the construction of restraining barriers for the protection of the Sacramento and Feather rivers in California, two hundred and fifty thousand dollars, such restraining barriers to be constructed under the direction of the Secretary of War in accordance with the recommendations of the California Débris Commission, pursuant to the provisions of, and for the purposes set forth in, section twenty-five of the Act of the Congress of the United States, entitled 'An Act to create the California Débris Commission and regulate hydraulic mining in the State of California,' approved March first, eighteen hundred and ninety-three: *Provided*, That the Treasurer of the United States be, and he is hereby, authorized to receive from the State of California, through the debris commission of said State, or other officer thereunto duly authorized, any and all sums of money that have been, or may hereafter be, appropriated by said State for the purposes herein set forth. And said sums when so received are hereby appropriated for the purposes above named, to be expended in the manner above provided," and for the further purpose of making available to the United States the appropriation, or any part thereof, made by the provisions of an act of the legislature of the State of California, approved March seventeenth, eighteen hundred and ninety-seven, entitled "An act to amend an act entitled 'An act to provide for the appointment, duties, and compensation of a débris commissioner, and to make appropriation to be expended under his directions in the discharge of his duties as such commissioner, approved March twenty-fourth, eighteen hundred and ninety-three,'" and of said amended act, the Secretary of War is hereby authorized, in the preparation for and construction of the proposed works authorized and appropriated for by the aforesaid provisions, to enter into an agreement that the contractor shall look solely to the State of California for one-half of such expense, to be paid out of said State appropriation, and the United States shall in no manner be liable for said one-half.

EXTRACT FROM RIVER AND HARBOR ACT OF CONGRESS, APPROVED MARCH 3, 1899.

That the provisions of an Act of Congress, entitled "An Act making appropriations for sundry civil expenses of the Government for the fiscal year ending June thirtieth, eighteen hundred and ninety-nine, and for other purposes," approved July first, eighteen hundred and ninety-eight, authorizing the Secretary of War, in expending certain specified appropriations in the preparation for and construction of certain works for the restraining or impounding of mining débris in the State of California, to enter into a contract or contracts wherein the contractor or contractors shall look solely to that State for one-half of such expense, and that the United States shall in no wise be liable for said one-half, are hereby extended to any appropriations, when made, that may hereafter be made for said purposes.

That the Secretary of War, in carrying out the provisions of any Act of Congress providing for the restraining or impounding of mining débris in California, may, in his discretion, when in his judgment the aggregate of appropriations already made by said State and Congress and available therefor are sufficient to complete the same, undertake the works necessary thereto by hired labor and by purchase of supplies and materials therefor, and may accept payments on account thereof as the work progresses under and according to the provisions of the acts of the legislature of said State for such purposes.

APPENDIX B B B.

DETERIORATION OF RIVER AND HARBOR WORKS, AND DISCONTINUANCE OF APPROPRIATIONS FOR RIVER AND HARBOR WORKS DEEMED NOT WORTHY OF FURTHER IMPROVEMENT.

[Printed in House Doc. No. 230, Fifty-sixth Congress, first session.]

Office of the Chief of Engineers,
United States Army,
Washington, December 2, 1899.

Sir: The river and harbor act of March 3, 1899, provides as follows:

Sec. 7. That the Secretary of War shall cause the Chief of Engineers of the United States Army, in submitting his annual reports to Congress with regard to works of river and harbor improvement under his charge, to state what deterioration, if any, has taken place by destruction, decay, obstructions, or otherwise, in connection with any of such works, together with an estimate of the cost of rebuilding or repairing such works, or removing such obstructions; and he shall also cause the said Chief of Engineers

to recommend, with his reasons therefor, the discontinuance of appropriations for any river and harbor work which he may deem unworthy of further improvement.

The same act also provides that—

Appropriations made for the respective works herein named, or so much thereof as may be necessary, may, in the discretion of the Secretary of War, be used for the repair and restoration of said works whenever from any cause they have become seriously impaired, as well as for the further improvement of said works.

My Annual Report for the fiscal year ending June 30, 1899, contains the following paragraph:

The river and harbor act approved March 3, 1899, provides that appropriations made for the works therein named may be used, in the discretion of the Secretary of War, for the repair and restoration of such works, as well as for the further improvement of said works. It also requires the submission of a report by the Chief of Engineers, stating what deterioration, if any, has taken place in the various works by destruction, decay, obstructions, or otherwise, in cases of works, together with an estimate of cost of rebuilding or repairing such works or removing such obstructions. On account of these provisions of law estimates are submitted for repair and maintenance as well as for continuing or completing improvements. Many of the works for which such estimates are presented have been deteriorating for many years, the appropriations for continuing work not being available for repairs or not being sufficient to permit proper work to be carried out. The repair work is, in many cases, more important than extension of improvement.

The essential features of the report desired as to deterioration are given in a general way in my Annual Report, and all such facts in a more detailed form will be made a part of future Annual Reports, as now provided for by law.

The object of the deterioration report is understood to be to give opportunity for considering the propriety of restoring and preserving old work, so that it may continue to satisfy the conditions for which originally carried out, and in many cases form a part of new and enlarged schemes of improvement. It is believed the object of the requirement of law will be fully accomplished by giving consideration to the estimates submitted in Report for 1899 for maintenance, and such as may be given in future reports, and that with the allowances so made, works may be gradually repaired and improvements restored.

For many works repairs have been virtually kept up, and for others new and extended projects have been made to include repairs; and for others, in accordance with approved projects, maintenance funds have been, for some time back, provided by the river and harbor acts and other legislation.

In addition to the information to be found in the Annual Report for the various items of improvement, there is appended hereto a statement giving some facts regarding certain works, based on the special reports received from officers in local charge of engineering districts, but if favorable consideration is given to the estimates submitted in Annual Report, it is not thought the items given in the appended statement require any action at the present time, as all such information will be revised and incorporated in the next Annual Report. The appended statement of works must not be considered as including all the works in connection with which repair and restoration must be considered, but simply those for which additional notes appear desirable. (See Table A.)

The river and harbor act of March 3, 1899, also requires the Chief of Engineers to recommend, with his reasons therefor, "the discontinuance of appropriations for any river and harbor work which he may deem unworthy of further improvement."

In the Annual Report presented by the Chief of Engineers for the fiscal year ending June 30, 1899, consideration is given to 520 works of improvement. A portion of these works so affect the general commerce of the country as to be national in their character; others are of commercial importance to local commerce; others appear to have for their object the possible building up of a future commerce; others may appear to those without local interests to be of little commercial importance or even personal in character, and still others, which at one time appeared of importance and justifiable, may through changes of conditions be no longer worthy of continuance.

With the different classes of works of improvement merging into each other it is not an easy matter, except in extreme cases, to draw the line which shall separate those of commercial importance from those which should not be continued by the General Government, and especially for the reason that all the improvements now being carried on have been considered and inaugurated by Congress, the authority which may most properly determine what facts and arguments should be accepted as giving evidence of the worth of an improvement.

The engineer officers in local charge of engineering districts were called upon by the Chief of Engineers for reports as to which, if any, of the works in their charge should, in their opinion, be discontinued, and the statements in Table B are based upon the reports received.

In connection with such statements reference, with two exceptions, is only made to works included in the Report of the Chief of Engineers for the fiscal year ending June 30, 1899. Works which have been dropped from such Report or previous ones, owing to nonappropriation for a number of years of money for continuance, have not been considered.

In addition to the works named in Table B, 115 works are included in my Annual Report for year ending June 30, 1899, for which no estimates for year 1901 are submitted. In some of these cases the available balances are sufficient to complete and in others to provide for all work immediately necessary. In others new surveys have been provided for and new estimates will be given in the reports thereon, and in some others it appears desirable to defer for the present a decision whether the work done or contemplated is justified by the commerce developed or anticipated.

Very respectfully, your obedient servant,

John M. Wilson,
Brig. Gen., Chief of Engineers,
U. S. Army.

Hon. Elihu Root,
Secretary of War.

Table A.

SPECIAL STATEMENT AS TO DETERIORATION OF RIVER AND HARBOR WORKS.

[General information upon these as well as other works will be found under the special items in Annual Reports.]

Union and Penobscot rivers, Maine.—Some parts of the channels dredged in the past in these rivers have been reduced in depth by

deposits of mill waste, but it is hoped that under the systematic method of improvement now being carried on such deterioration will not result in the future,

Plymouth Harbor, Massachusetts.—The severe storms of the winter of 1898–99 seriously damaged the protective works on Long Beach. The estimated cost of repair is $95,700. The river and harbor act of March 3, 1899, appropriated $75,000 for this work, and an estimate of $20,700 for completion is presented in my Annual Report for the year 1899.

Breakwater at Sandy Bay, Massachusetts.—This breakwater was built by the United States Government in 1836–1846, at a cost of $69,232.57, the object of the improvement being to provide a shelter from easterly storms for the coasting vessels of that period. The original height of the breakwater was about 14 feet above high water, but this has been cut down by the action of the sea, so that the average height is but about 4 feet above high water. The cost of restoring the breakwater to its original height is $28,564.25. To restore to a height of 10 feet, which height will probably furnish adequate shelter to the wharves from easterly storms, will cost approximately $18,128. This work, which is not included in my Annual Report, is interior work and is not to be confounded with the "harbor of refuge, Sandy Bay, Cape Ann."

Harbor of refuge at Nantucket, Mass.—The project for this work provides for construction of two jetties. Since the jetties have been in course of construction more or less damage has been done them by ice and storms. It is estimated that the amount required to repair such damage in addition to amount required to complete project is $30,000.

Harbor of refuge, Point Judith, Rhode Island.—The breakwater forming this harbor has been damaged materially by severe storms, but all such repairs can be made in connection with the further extension of the work, for which an estimate is submitted.

Harbor of refuge at Block Island, Rhode Island.—The breakwaters at this harbor have been injured more or less by storms, and it is estimated that to restore them to original height and repair deterioration will cost $67,500.

Connecticut River, Connecticut.—The west jetty at the mouth of the river has not been repaired for several years, and its efficiency as a dike and breakwater has been appreciably impaired. It is estimated that the amount required to repair this dike is $10,000.

Hudson River, New York.—In connection with this improvement many dikes have been constructed, which deteriorate with age; much repair work has been carried out as part of improvement. For the restoration of works and their maintenance the officer in local charge estimates that an appropriation of $100,000 a year will be required in addition to estimates for completion.

Ocracoke Inlet, North Carolina.—To restore channel to project depth of 9 feet would require an expenditure of about $40,000, but existing depths appear to be ample for present needs of navigation.

Neuse River, North Carolina.—To repair and renew regulating works between Newbern and Kinston will cost $50,000.

Inland waterway between Beaufort Harbor and New River, North Carolina.—All the cuts through Bogue Sound have shoaled, and to restore to original width and depth will cost $10,000.

Black River, North Carolina.—Owing to cessation of work for two years obstructions have accumulated. The former good condition can be restored for $5,000.

Cape Fear (Northeast) River, North Carolina.—Suspension of work for two years has allowed obstructions to accumulate. It can be cleared again at an estimated cost of $6,000.

Cumberland Sound, Georgia and Florida.—While deterioration has taken place, it is impossible at present time to make estimate of amount required for restoration. It is probable that restoration can be made in connection with completion, for which an estimate is submitted.

St. Johns River, Florida.—In the river proper there has been shoaling between Dames Point and the mouth. To restore this channel to its former condition will cost about $47,000.

Indian River, Florida.—Without doubt deterioration has taken place in the dredged cuts, but no estimate can be made at present time of cost of restoration.

Alabama, Chattahoochee, Flint, Apalachicola, Choctawhatchee, Escambia, and Coosa rivers.—All the dikes and training walls in these rivers have deteriorated more or less, but they are repaired from time to time in connection with new work, and a detailed estimate of the cost of such repairs can not now be made.

Tombigbee River, Alabama, from its mouth to Demopolis.—In addition to $15,000, estimated in Annual Report for 1899 for maintenance, the cost of repairing snag boats will be $10,000.

Pascagoula River, Mississippi.—Snags, logs, etc., have not been removed from this river since 1886. To clear out the river again will cost, it is estimated, $12,500, being $7,500 in excess of the estimate submitted for maintenance during year 1901.

Water gauges on the Mississippi River and its principal tributaries.—Most of the large bulletins at the gauges on the Mississippi are worn out, and the annual appropriation for maintenance of these gauges is not sufficient to provide for proper repair. It is estimated that the cost of 12 new bulletins, now required, would be $2,700. This amount is not included in the estimates given in my Annual Report.

Arkansas River, Arkansas.—Works constructed for the improvement of the Arkansas River were damaged by the flood of May, 1898, and subsequent high water. It is estimated that the proper repair and maintenance of these works will cost $50,000, and an estimate of such amount is given in my Annual Report.

Mississippi River between Ohio and Missouri rivers.—Works for the permanent improvement of this stretch of the river are subject to destruction and decay in some instances before their full object is accomplished, but such damage is considered incidental to the character of the work and provided for in the estimate for general improvement.

Following each high water in the Mississippi River, obstructions in the nature of sand bars appear in reaches in which permanent improvement has been only partially completed or not commenced. These obstructions must be removed annually at a cost estimated to be $150,000.

Mississippi River between mouth of Missouri River and St. Paul.—Some deterioration of the works built for permanent improvement of this stretch of river must be expected, but such work is provided for in connection with permanent improvement.

Construction of reservoirs at head waters of Mississippi River.—Four of the reservoir dams constructed of timber have so deteriorated that their extensive repair is necessary. Provision has been made for repair of the dams at Winnibigoshish and Leech lakes. The dams at Pine River and Pokegama Falls will also require rebuilding as soon as possible, at a cost of about $100,000. The estimate submitted in my Annual Report will provide for such work.

Missouri River between Stubbs Ferry and the lower limits of Sioux City, Iowa.—The works heretofore constructed on the various sections of this river have deteriorated, and it is estimated the cost of restoring them to original condition would be about $40,000.

Ohio River.—The original project for improving this river included the construction of low dams across chutes and dikes when the river is wide, dredging, removal of rock, bank protection, and ice piers. To thoroughly repair all the dikes and restore dredged channels is estimated to cost $421,800. But under the modified project, which also includes the construction of movable dams, many of the dikes have become of less importance. The full repair of all dams from Pittsburg to Cairo is not immediately necessary, and the estimate of $200,000 for maintenance submitted in Annual Report for such work will provide for all present necessities.

Monongahela River, West Virginia and Pennsylvania.—Considerable deterioration has taken place in the locks and dams on the Monongahela slack-water system, especially on the locks and dams purchased by the Government from the Monongahela Navigation Company, but available funds will provide for gradually placing the works in proper condition.

Allegheny River, Pennsylvania.—Contraction works on this river have suffered from decay and effect of ice and floods, but estimate presented in Annual Report for maintenance will provide for present needs.

Muskingum River, Ohio.—Lock and Dam No. 11, above Zanesville, is so dilapidated by decay as to be useless. It has never been restored or used since the United States took charge of the system. To put it in good condition will cost about $110,000. All other locks and dams are maintained under an indefinite appropriation, but it is not considered permissible to apply an allotment from such appropriation to the reconstruction of Lock and Dam No. 11.

Ashland Harbor, Wisconsin.—A large portion of the breakwater at this point is old and rotten above the water line. Ultimately about 5,700 feet of superstructure will have to be renewed at a cost of $57,000. An allotment for repair work is now available, and an estimate of $15,000 for continuing the repair work is submitted.

Harbors on Lake Michigan.—At the many harbors on this lake deterioration of old piers, etc., has taken place, and estimates for such restoration and maintenance as is necessary immediately are given in Annual Report under each special heading. Further expenditure for additional repair will be desirable in the near future.

Calumet Harbor, Illinois.—There is 500 feet of superstructure of old pier and some revetment in this harbor requiring repair and renewal, the cost of which is estimated at $14,500.

Sandbeach harbor of refuge, Michigan.—The whole timber superstructure of this breakwater is in an advanced state of decay. Provisions were made in last river and harbor act for rebuilding a portion

in stone, and it is believed the full and complete repair and permanent restoration of this work will cost $250,000 in addition to amount heretofore provided for.

Ashtabula Harbor, Ohio.—All of the south pier is in poor condition, and parts, if maintained, must soon be rebuilt. The total length to be rebuilt is about 1,330 feet, which to rebuild in concrete is estimated at $115 per foot. Parts of revetment should be rebuilt, and certain parts now in good condition should be sheathed, to prevent wear and tear. The total cost of such work is estimated to be $176,960. Work is now in progress at this harbor under a new project, and if the appropriations recommended for maintenance are made old work may in time be repaired and made sufficiently serviceable.

Huron Harbor, Ohio.—A large portion of the old piers at this point is in such bad condition as to make rebuilding desirable. The officer in local charge estimates the cost of restoring old piers to be $176,000. Some of the necessary work will be done with available appropriation.

Fairport Harbor, Ohio.—To restore portions of the old piers at this point the officer in local charge estimates would cost $132,540.

Dunkirk Harbor, New York.—The officer in local charge estimates that the work immediately necessary for repair of old piers will cost about $20,000.

At many other points on lakes Huron, Erie, and Ontario.—Where timber piers exist repairs and restoration are necessary, but special estimates of cost are not presented, and such work as is desirable will be provided for from maintenance appropriations.

Coquille River, Oregon.—No work has been done on the north jetty since 1892, and the officer in charge estimates it will cost to restore tramway and jetty to former condition about $36,000.

Entrance to Coos Bay and Harbor, Oregon.—Since work was suspended in 1897 the north jetty and pile tramway have deteriorated, and the officer in local charge estimates it will cost $63,000 to restore to former condition.

Tillamook Bay and Bar, Oregon.—The cost of repairing dikes and restoration of certain channels in connection with this improvement is estimated by officer in charge to be $6,700.

TABLE B.

LIST OF RIVER AND HARBOR WORKS REQUIRING SPECIAL MENTION IN CONNECTION WITH FURTHER APPROPRIATIONS FOR IMPROVEMENT.

Repair of sea wall at Marblehead, Mass.—In accordance with provisions of river and harbor act of June 3, 1896, an examination was made of Marblehead Harbor, Massachusetts, "with a view to improving the harbor by building a sea wall to protect the isthmus connecting Marblehead Neck with the town of Marblehead." As a result of the examination it was reported that there appeared to be no danger of the sea making a breach in the isthmus, to the injury of the harbor. A recent personal examination by the engineer officer in charge of this work leads him to report that the existing sea wall, built early in the present century, is well protected and is not in need of any repairs, and the expenditure of the $1,000 appropriated by act of March 3, 1899, does not appear to be necessary.

Harbor at Vineyard Haven, Mass.—The project for this work provides for the protection of bluffs and headlands from erosion, to prevent shoaling of the anchorage area. No further work of this kind appears to be necessary. Maj. D. W. Lockwood, the engineer officer in local charge of this work, in recommending a discontinuance of appropriations, states:

My reasons for the above are that, as stated in my annual report for 1898, the present project is completed and no further work of the kind is required. This work consisted in protecting the headlands and bluffs from erosion, the object being to prevent shoaling of the anchorage area by the washing into it of the eroded material. It has always seemed to me that the landowners of the bluffs and headlands were much more interested in this improvement than the vessel people. This work is entirely independent of what is sought to be accomplished by the examination called for in the river and harbor act of March 3, 1899, as the latter has special reference to the protection of the anchorage area between the East and West chops by means of an exterior breakwater.

Entrance to Point Judith Pond, Rhode Island.—This work if completed would have little commercial importance, and the interests involved are not sufficiently great to justify the cost of construction and maintenance. Major Lockwood states in his report:

This work, if completed, would have little, if any, commercial importance. The pond itself is shallow, and the entrance to it from the sea has shifted from time to time along almost its entire front. Only a small class of vessels could use the pond as a harbor if the entrance were made sufficient, and the expense of making this and maintaining it would be great.

This locality has been reported as unworthy of improvement by General Warren in 1873 (pp. 286–289, Part II, Annual Report of the Chief of Engineers for 1874), also in 1888 by Major Livermore (pp. 642, 643, Annual Report of the Chief of Engineers for 1889), and also in 1893 by Major Bixby (pp. 841–879, Annual Report of the Chief of Engineers for 1893). I fully concur in the conclusions of these officers, and would respectfully recommend not only the discontinuance of further appropriations, but the return to the United States Treasury of the amount now available.

Rancocas River, New Jersey, including the Lumberton Branch.—Under existing conditions it is believed the establishment and maintenance of increased channel depths would cost more than is justified by the commercial benefits that would probably result from the improvement. Lieutenant-Colonel Raymond reports that—

The only stream in my charge deemed unworthy of further improvement is the Rancocas River, New Jersey, including the Lumberton Branch, concerning which full reports were submitted under dates of November 15 and November 17, 1894. In these reports I expressed the opinion that under existing conditions the establishment and maintenance of increased channel depths in this river would cost more than is justified by the commercial benefits which would probably result from the improvement, and that it would not be advisable for the Government to undertake the improvement of the Lumberton Branch unless the channel depths in the main river are to be maintained. In my annual report for this year no further appropriation is recommended for this work.

Manokin River, Maryland.—While an estimate is submitted for continuing improvement and maintenance, it is questionable whether a continuance is justifiable owing to the fact that the expense of maintaining the dredged channel will be great and commerce appears to be reduced. Gen. W. F. Smith, United States agent, reports as follows:

In compliance with General Orders, No. 4, headquarters Corps of Engineers, current series, I have the honor to report that there is one work of improvement under my charge for which I recommend that no further appropriation be made, namely, Manokin River, Maryland. I make this recommendation on account of the difficulty of maintaining the dredged channel, except at great expense, and of the very considerable reduction in the commerce of the river.

Protection of Jamestown Island, Virginia.—The protection of this island can not be said, at the present time at least, to be necessary in the interest of navigation or to form any part of the plan for the improvement of the channel of the James River.

St. Augustine Harbor, Florida.—There is no commerce to be benefited by this improvement. Captain McKinstry reports:

The total estimated cost of the improvement, as estimated above, is $95,000. Seventy-one thousand dollars has been appropriated, $64,999.90 has been expended. Seven groins and a wing dam have been constructed. To complete the project there remain to be constructed two groins and certain wing walls and beach revetments.

It is recommended that appropriations for this work be discontinued, for the reason that all water commerce at this port has ceased. Attention is invited to the Annual Report of this year, in which it is stated that the collector of customs reports that there was no water commerce at this port during the year ending December 31, 1898.

Coosa River, between the East Tennessee, Virginia and Georgia Railway Bridge and Wetumka, Ala.—The project for this reach of river contemplates construction of 23 locks and dams and cutting channels through rocky reefs. No commerce can be developed until work is completed, and at present time the future amount can not well be predicted. Unless appropriations can be made very large, that is, sufficient in amount to complete this work within a reasonable time, it might as well be dropped.

Cypress Bayou, Texas and Louisiana.—Work done since 1886 has not increased commerce; in fact, commerce has become insignificant. Major Willard states:

In view of the changed conditions since this work was undertaken by the United States, the fact that there is no prospective commerce to warrant slack-water navigation, that there is no steamboat trade and no probability that any will be revived, and that there has been no stage in two years on which a boat could enter the lakes, I am of the opinion that this work is unworthy of further improvement, and recommend that the unexpended balance of former appropriations revert to the Treasury

Chippewa River, Wisconsin.—The great expense attending the permanent improvement of this river is not justified by the amount of the class of commerce that would be materially benefited by such improvement. Major Abbot states that:

The commerce on the river is not sufficient to justify the continuance of further appropriations for this stream. It consists mainly in floating rafted lumber and in running loose logs. One steamer towing rafts does run on the lower part of the river, but the stream is so wide and divided into so many channels as to make any real improvement inordinately expensive.

Minnesota River, Minnesota.—No commercial benefits have resulted from work heretofore carried out on this stream. Major Abbot states:

No further sums should be appropriated for this stream, as the expenditure of over $130,000 has resulted in absolutely no lasting improvement and no commercial benefit.

Bar at mouth of Warroad River, Minnesota.—The propriety of doing any work here appears to depend on the stage of water to be hereafter maintained in Lake of the Woods by the operating of the dam at Rat Portage in Canadian territory. Until this question is settled no consideration can well be given to question of improvement. Major Abbot states:

Communication has been had with the owners of the dam and their intentions are in brief as follows: If they can sell the power they have created they will maintain the lake at the level it had in May, 1899. In that case no work is necessary. If they can not sell their power they will leave the dam open, the lake will fall approxi-

mately 3 feet, and in that case a great deal of work will be necessary to improve the bar so that the boats now navigating the lake can enter. No further appropriations should be made until further developments show at what stage the lake is to remain.

Red River of the North, Minnesota and North Dakota.—The main argument for continuing this improvement appears to be that it will be a possible controller of railroad rates. While not recommending a discontinuance of appropriations at present time, the officer in local charge considers such subject should have further consideration in the future. Major Abbot states:

I have the honor to report that the work of dredging on the Red River of the North is not permanent, the channels filling up by landslides from the bank. Such a landslide of large extent has been caused by the railroad embankment of the Northern Pacific Railroad at Grand Forks, N. Dak. There is some commerce on this river below Goose Rapids. To keep the channel dredged will require $10,000 annually. The commerce is about 17,000 tons per annum, valued at, perhaps, $300,000. There are railroads along each bank.

As a private investment the expenditure of $10,000 annually for the river would be folly; as a possible controller of local railroad freight rates it may be justified by the United States, but it is so doubtful that I recommend appropriations of the amount named for three years only; at the end of which time I consider that this section of the river should be again reported upon.

Above Goose Rapids there is no commerce, and the improvement of that section should be abandoned.

Red Lake River has some commerce on it, but all that can be reasonably accomplished for its improvement will be completed this season, unless the survey for a reservoir in Red Lake shows such to be feasible. Until such time no further appropriations should be made for Red Lake River.

Missouri River, between Stubbs Ferry, Montana, and the lower limits of Sioux City, Iowa.—While commerce may to a limited extent be interested in the improvement of certain portions of this stretch of river, the main object of the improvement appears to be for land protection; but improvements which have been commenced at a number of points are now in an unfinished condition, and would be liable to be destroyed if no further work is done. The suspension of appropriation is not, therefore, now recommended, but it is thought appropriations should be so made as to permit the protection of work heretofore carried out rather than to provide for inauguration of new work. In connection with these works, Captain Sanford submits the following statements:

Stubbs Ferry to Greatfalls.—Continuance of appropriations is recommended, at least until the work is completed between Greatfalls and Cascade, the estimated cost of completing which portion is $84,509. Before work on this section is completed further data will be obtained and a report made regarding the advisability of improving, in accordance with the adopted project, the section between Cascade and Stubbs Ferry.

At Fort Benton.—No further appropriation is needed, the available funds being sufficient to complete the work desired, which is the protection of property. There is no navigation on this part of the river.

At Judith.—If the $5,000 appropriated by the river and harbor act of March 3, 1899, is to be expended, a further appropriation of $5,000 should be made to complete the work desired, which is the protection of property. The expenditure of $5,000 alone will be of very little benefit. There is no navigation on this part of the river, but a part of the erosion that has occurred, only a comparatively small part, it is believed, has been due to the effect of a dam built by the Government in 1891.

Carroll to Sioux City.—Appropriations have been made, beginning with the act of August 18, 1894, for work on the following reaches within the above limits: Bismarck, Pierre, Yankton, Elkpoint, and Sioux City. General plans for the improvement of these reaches, the plans covering from 2 to 10 miles of river, have been submitted, and the work done in accordance with these plans at all the localities except Elkpoint. Work at Elkpoint is soon to be begun. A discontinuance of appropria-

tions for any of these reaches is not now recommended, in view of the unfinished character of the improvements and the exposure of the works to destruction if no further work is done than funds now available will permit. Of the above reaches, however, that at Bismarck is the only one the improvement of which directly benefits present river commerce, except ferrying; but only part of the works proposed for this reach are of sufficient benefit to navigation to justify their cost on that ground alone. At Yankton the river commerce, except ferrying, is prospective only. Here part of the general plan provides for restoring the steamboat landing and part for training the river as it approaches the site of a proposed drawbridge, about 3 miles above Yankton, which, however, may not be built. At Pierre the only river commerce is ferrying, but the amount of this is large. At Sioux City navigation is interested only in that part of the general plan which provides for controlling the river above a drawbridge. There is now little navigation at Sioux City. At Elkpoint navigation is practically not concerned at all in the proposed works.

From the above it appears that the improvement of the reaches named depends for the most part for its justification on the value of property protected. This value, combined with the value of the works to navigation at certain points, is, in each of the above reaches, greater than the cost of most of the works proposed. (It is thought that for some of these reaches the general plans can hereafter be advantageously modified and the total cost reduced.)

Yellowstone River, Montana and North Dakota.—There has been no navigation on this river in recent years, and resumption appears unlikely. With the exception of a small amount for maintenance of work at Glendive, no further appropriations appear necessary at the present time.

New River, Virginia and West Virginia.—No work has been done on this river since 1889, and the cost of further improvement would be out of all proportion to the benefits to be conferred. Captain Hodges states:

Work on this improvement has ceased for ten years, during which time there have been no funds appropriated, although there has been a balance of about $2,300 on hand. Under date of April 17, 1891, Gen. (then Col.) W. P. Craighill, Corps of Engineers, reported against further expenditure on the river, stating in substance that the railroads had taken most of the trade which could be accommodated by the river if improved according to the existing project by open-river regulation, and that the time was not yet ripe to initiate more expensive improvements by locks and dams, which alone could restore the importance of the waterway.

There is no reason at present to depart from the views stated in his report.

The expense of further improvement of the stream, even under the present project, is very large in proportion to the results attained, since a great deal of rock excavation must be done, while the cost of canalizing the river would be out of all relation to the benefits to be derived now or in the near future.

Under date of June 27, 1899, authority was received from the Chief of Engineers to drop this work from annual and monthly reports subsequent to those rendered in July, 1899.

Elk River, West Virginia.—An examination of this river was ordered by river and harbor act of March 3, 1899, and attention is respectfully invited to report thereon. Captain Hodges states:

A preliminary examination with the view of establishing locks and dams was made in 1890, and the river was reported by General (then Colonel) Craighill as unworthy of such improvement. (A. R. C. E., 1891, p. 2433 et seq.)

Another preliminary examination[1] was ordered in the act of March 3, 1899, and will soon be made.

The funds remaining available will probably all be spent in the open-river work during the coming season.

In my judgment further appropriations for work under the present project should not be asked, nor should they be made for the slack-water system until the preliminary examination has been made and reported upon.

Kentucky River, Kentucky.—The present project for this river is to extend 6-foot navigation to Beattyville by construction of locks and dams. Seven dams are in operation, the eighth is partially finished, and six more remain to be built. Work is now carried on under pro-

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[1] Report printed in House Doc. No. 70, Fifty-sixth Congress, first session.

visions of acts of Congress which contemplate a certain limit of expenditure. Such limit will not carry slack water to Beattyville, and when the work is completed to the extent permitted by existing legislation the subject of extending the improvement will be a proper one for consideration.

Wabash River, Indiana and Illinois.—Appropriations have heretofore been made separately for sections above and below Vincennes. The officer in local charge is of the opinion that this improvement should be carried on as a unit, commencing at the lower end, and that upper section is not worthy of improvement until improvement of lower section is provided for. Captain Zinn states:

> With the lower Wabash improved, as suggested in report of this date for "below Vincennes," it would be possible to extend the improvements over the river above Vincennes, so as to afford through-water transportation between the mouth of the river and Terre Haute, Ind. But until the object is to provide and maintain such navigable through channel, further expenditure is not recommended, because the benefit would be purely local and of no general advantage to commerce. If the recommendations concerning the river "below Vincennes" meet with approval, then it is recommended that the matter of extension of improvements and maintenance over the river "above Vincennes" be included therein, and the whole subject considered in one project, having for its object the completion and maintenance of a through navigable channel of specified minimum width and depth, but limiting the application of funds so as to require that work done will be toward making the channel continuous from the mouth upstream.
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> The recommendation that work be commenced at the mouth of the river and a navigable channel be maintained throughout the reach improved is adhered to, because it is believed that no general benefit will be derived until the improvements are such as to render it possible for a line of boats to navigate regularly, and unless such is the case it is certain that the lock already completed and in operation will not prove any great advantage to the general traffic and commerce of the section of country through which the river flows. It is not believed that local interests at different points are of sufficient importance to justify improvement of detached pools or reaches. In view of the foregoing, it is respectfully recommended that the improvement of the river be continued in the manner outlined above, and that the amount necessary for making a complete survey of the river below the lock—$20,000—(Annual Report, Chief of Engineers, 1898, p. 1980) be made available at one time, in order that the survey may be completed without interruption.

White River, Indiana.—Commerce originating on White River can not find an outlet until the lower portion of the Wabash River is improved, and may properly follow the Wabash improvement.

Pensaukee Harbor, Wisconsin.—A further improvement of this harbor would be of no benefit to commerce.

South Milwaukee Harbor, Wisconsin.—There is but small area available for an interior basin, and the resulting harbor would be inadequate for a commerce commensurable with the cost of making an entrance, and the expense of an outside harbor would be much greater than the interests involved warrant.

Chicago Harbor and Chicago River, Illinois.—Contracts for these works were let under appropriations made by acts of March 3, 1899, but all dredging work under such contracts has been temporarily prohibited as a result of prohibition by the city of Chicago, of dumping within certain limits. Until this question of dumping, which appears to be an issue between the United States and the city of Chicago, is settled, the expenditure of existing or future appropriations for dredging will be a matter for very serious consideration.

Outlet to Wolf Lake, Indiana.—The river and harbor act of June 3, 1896, appropriated $8,000 for this work, in accordance with the approved project. The same act required a survey of Wolf Lake and

River. There being no approved project for this improvement, no work has been undertaken. In reporting upon the survey[1] it was stated that the work was not a public necessity or worthy of being undertaken by the General Government.

Black River at Port Huron, Mich., above Grand Trunk Railway Bridge.—Work above the bridge was inaugurated by act of July 13, 1892, but commerce is very limited and channels are not permanent.

Rouge River, above Wabash Bridge, Michigan.—Not considered justified at present by commerce involved.

Vermilion Harbor, Ohio.—To put existing piers in such condition as to protect the channel would probably cost $50,000 if expended in one sum, and more if expended under smaller appropriation, and the benefits would be very small until the work is completed. The commerce of port would not appear to justify such an expenditure.

Wilson Harbor, New York.—An estimate is submitted for maintenance of this harbor, but as it is of but little commercial importance the propriety of such maintenance is questionable.

Pultneyville Harbor, New York.—This harbor is of but little commercial importance.

Port Orford Harbor, Oregon.—The commercial importance of this harbor is insignificant when considered in connection with the enormous sum required for adequate protection. Captain Harts states:

> The present project of extending a wharf southward from Port Orford, as called for in the above-mentioned act of Congress, can in no way be used for refuge when the natural protection of the headland does not already protect this area, and the benefit to general commerce by any so-called "wharf for commercial shipping purposes," built at public expense, would be trifling, for, as is above stated, present accommodations are already sufficient. For these reasons this project is considered wholly an unworthy one.

Coquille River, Oregon, between Coquille and Myrtle Point.—The project for improving this 13 miles of river contemplates a depth of 4 feet at mean low water. Such depth existed June 30, 1899, except for upper 3 miles, for which depth was 1 foot. It is doubtful if the full depth of 4 feet can be maintained all the year round over the entire stretch, except at an expense not justified by the general commerce interested.

Umpqua River, Oregon.—While the depth of channel projected has not been fully secured at all points, it at present meets all requirements of commerce.

Mouth of Siuslaw River, Oregon.—This improvement is not considered to be justified by present commerce of river, but a further appropriation has been recommended in Annual Report, with a view to placing the work already carried out in a condition to have some effect on the river entrance.

Columbia River at Three-mile Rapids, Oregon.—The act of Congress of August 18, 1894, provided for commencing the construction of a boat railway from the foot of The Dalles Rapids to the head of Celilo Falls, "substantially in accordance with the location and plans submitted by the board of engineers appointed by the President in pursuance of the provision of the act of Congress approved July 13, 1892." Two hundred and fifty thousand dollars has already been appropriated for this work. The cost of the boat railway, as estimated in 1894, is about two and one quarter millions. Up to June 30, 1899, some preliminary work has been done and most of the land needed

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[1] See Report Chief of Engineers for 1897, Part IV, page 2887 et seq.

has been acquired, but the track of the Oregon Railroad and Navigation Company has not yet been moved and no actual construction has been commenced.

The Board to whose report reference is made stated—

that a portage railway will meet the urgent demands of the wheat district. * * * That the obstructions to navigation in the Columbia River from the navigable waters thereof below Three-mile Rapids to the navigable waters above Celilo Falls can be overcome in the most feasible, speedy, and economical manner, and in that best adapted to the present necessities of commerce and to its future development, by the construction of a portage railway. * * *

The engineer officer in local charge of this work makes the following statement:

I do not hesitate to report that in my opinion the proposed improvement by the construction of a boat railway, at an estimated cost of $2,261,467, at the present time is an unworthy one.

In my opinion the locality is at present time worthy of improvement only to the extent of constructing a portage road to pass commerce around the obstructions between The Dalles and Celilo.

Clearwater River, Idaho.—Owing to the steep slope of this stream it can not be permanently improved for navigation all the year round except at enormous cost, compared with which the commerce, present and prospective, is utterly insignificant.

Missouri River, from its mouth to Sioux City, Iowa.—This work is carried on under the Missouri River Commission constituted by act of July 5, 1884. From my Annual Report for 1899 the following extract is given:

The systematic plan under which the Commission is working, to such an extent as the appropriation acts permit, is that of the permanent improvement of the river in reaches, commencing at the lowest reach, as provided for by law. It is only by the application of appropriations to such systematic work that the improvement of the Missouri River can be accomplished. Allotments from the appropriations for work in detached localities can do but little good at such points, and all such allotments interfere materially with the progress of the systematic improvement, increase its cost, and postpone the time when commerce will commence to reap full benefit from the improvement. In fact, it can be stated that unless the appropriations for this river can be so made as to permit its expenditure for the systematic improvement of the river rather than to require subdivision and expenditure in many special localities, the appropriation might as well be omitted so far as the interests of navigation are concerned.

Lower Mississippi River.—These works are carried on under a Commission and the work being done is in accord with "the plans, specifications, and recommendations of the Mississippi River Commission, as approved by the Chief of Engineers," and the work contemplated by the law is general improvement, surveys, building and repair of levees, "to be made and carried on in such manner as in their opinion shall best improve navigation and promote the interests of commerce at all stages of the river." The estimates for works of improvement on the Mississippi River from Cairo to the Head of Passes are simply submitted as recommended by the Commission, it being understood such is the intent of the law.

APPENDIX C C C.

OCCUPATION OF PUBLIC RIVER AND HARBOR WORKS BY PRIVATE PARTIES.

[Printed in House Doc. No. 72, Fifty-sixth Congress, first session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, November 23, 1899.

SIR: The river and harbor act approved March 3, 1899, contains the following item:

SEC. 8. That the Secretary of War is directed to cause to be prepared and reported to Congress a list of all piers, wharves, and other structures or property pertaining to river and harbor works belonging to the Government of the United States now occupied by private corporations or persons, together with the terms upon which such piers, wharves, or other property are occupied, and the date of the agreement or permission granting the privilege to occupy the same, and shall make such recommendations as he may deem desirable in connection therewith—

and I now have the honor to submit the accompanying paper containing the information called for by the provision of law referred to.

Section 14 of the act of Congress, river and harbor act of March 3, 1899, would appear to provide for all questions arising in connection with occupation of such Government property as is considered in this report, and no further legislation appears necessary or is recommended.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Hon. ELIHU ROOT,
Secretary of War.

List of piers, wharves, and other structures or property pertaining to river and harbor works belonging to the Government of the United States and occupied by private corporations or persons, submitted in compliance with the provisions of section 8 of the river and harbor act approved March 3, 1899.

United States property occupied by private parties.	By whom occupied.	Purpose for which held.	Terms under which held.	Date of authority.
Part of old crib work, harbor at Block Island, R. I.	C. C. Ball	Building purposes	No authority on record	
Hudson River improvement, N. Y:				
About 175 feet of Bronk's dike, 16 miles below Albany.	Bronk & Gay	Dock	Revocable license of Secretary of War	Nov. 13, 1896
About 300 feet of Mulls Island dike, 13 miles below Albany.	Miller & Whitbeck	do	Permit granted by Secretary of War	Nov. 9, 1880
About 100 feet of Barren Island dike, 12.5 miles below Albany.	H. Slingerland	do	No authority on record	
Cut about 6 feet wide through Coeyman's middle dike, 12.5 miles below Albany.	John N. Briggs	To float ice through from water outside to the ice house.	Revocable license of Secretary of War	Feb. 7, 1885
About 470 feet of Mulls Island dike, 12.5 miles below Albany.	do	Dock	do	Sept. 3, 1895
470 feet of Coeyman's north dike, 12.5 miles below Albany.	do	do	do	Apr. 16, 1891
About 180 feet of Roah Hook dike, 12 miles below Albany.	Sutten & Suderly Brick Co	do	No authority on record	
About 320 feet of Roah Hook dike, 12 miles below Albany.	Consolidated Ice Co. (formerly Knickerbocker Ice Co.).	do	Permit of Chief of Engineers, U. S. Army	Oct. 12, 1880
About 100 feet of dike across Hellegat Channel, 10.25 miles below Albany.	Consolidated Ice Co. (formerly C. E. Warren).	Dock, and opening about 6 feet wide for floating ice through dike.	No authority on record	
150 feet of Schodack Island half dike, about 10 miles below Albany.	Horatio D. Mould (estate of)	Dock	Revocable license of Secretary of War	Oct. 6, 1898
75 feet of the Castleton dike, 9.5 miles below Albany.	Consolidated Ice Co. (formerly Phipps).	do	No authority on record	
260 feet of dike just south of Castleton, 8.75 miles below Albany.	Consolidated Ice Co. (formerly F. E. Bean).	do	Grant of land under water from State of New York	
100 feet of Cedar Hill dike, 8.5 miles below Albany.	Consolidated Ice Co. (formerly The Ridgewood Ice Co.).	do	do	
Portion of Castleton dike, 8.5 miles below Albany.	E. P. Stimson	do	Permission of the Chief of Engineers	Sept. 11, 1871
282 feet of Cow Island single-pile dike.	Heirs of Archibald Scott (formerly Sunnyside Ice Co.).	do	No authority on record	
176 feet of Cow Island dike	do	do	do	
252 feet of Campbell Island half dike, 7.5 miles below Albany.	George N. Best & Co. (formerly Best & Carman, and Richard English).	do	Revocable license of Secretary of War	Sept. 6, 1890
450 feet of Bear Island dike, 6 miles below Albany.	Union Ice Co. (formerly Tillie & Littlefield).	do	No authority on record	

About 40 feet of Overslaugh dike No. 1, 3.5 miles below Albany.	John Patterson (formerly Houghtaling & Park, later Knickerbocker Ice Co.).	Dock	Revocable license of Secretary of War	Sept. 6, 1890
290 feet of Overslaugh dike No. 1, 3.5 miles below Albany.	John Patterson	....do	Two revocable licenses of Secretary of War	Dec. 16, 1881 Sept. 5, 1896
About 70 feet of Overslaugh dike, about 3 miles below Albany.	Owner of adjoining island	....do	No authority on record	
169 feet of Overslaugh dike No. 1, 3.5 miles below Albany.	Consolidated Ice Co. (formerly Knickerbocker Ice Co.).	....do	Revocable license of Secretary of War	Sept. 25, 1890
Opening about 100 feet wide in Papscanee dike, Section III.	Consolidated Ice Co	Passage for floating ice through.	No authority on record	
166 feet of Bogart Island dike, 2.25 miles below Albany.	Clark and Lawrence	Dock	Revocable license of Secretary of War	Oct. 20, 1890
75 feet of Bogart Island dike, 2 miles below Albany.	Consolidated Ice Co. (formerly Knickerbocker Ice Co.).	....do	....do	Sept. 25, 1890
12 feet of Cuyler dike and opening in same, about 40 feet wide.	Horatio D. Mould (estate of).	Dock and passage for ice	No authority on record	
Opening 40 feet wide in Small Island dike.	Schifferdecker Bros	Passage for floating ice through.	Revocable license of Secretary of War	Nov. 20, 1899 Nov. 12, 1898
75 feet of Bath dike, 1.5 miles above Albany.	Paul E. Forbes	Dock	Bond and agreement with Chief of Engineers	Oct. 28, 1876
225 feet of Bath dike, 1.5 miles above Albany.	W. H. Forbes	....do	Revocable license of Secretary of War	June 15, 1882
215 feet of Patroons Island revetment, 2.5 miles above Albany.	George Marks and others	....do	No known authority except old colonial grant	
South end of High dike, 3.5 miles above Albany.	Lagoon Island Syndicate	Fence, with post for support, partially outside of harbor line.	No authority on record	
100 feet of High dike, 3.5 miles above Albany.	Erastus Corning	Dock	Revocable license of Secretary of War	Do.
Few feet of Breaker Island revetment, about 4.25 miles above Albany.	Troy Steel Co	Outlet for waste pipe from boiler plant.	No authority on record	
About 120 feet of Port Schuyler dike, 4.25 miles above Albany.	....do	Ferry slip and dock	....do	
Few feet of Port Schuyler dike, 4.75 miles above Albany.	....do	Waste pipe from blast furnace.	....do	
528 feet of Port Schuyler dike, 4.75 miles above Albany.	....do	Dock	Grant of land under water from State of New York	

List of piers, wharves, and other structures or property pertaining to river and harbor works, etc.—Continued.

United States property occupied by private parties.	By whom occupied.	Purpose for which held.	Terms under which held.	Date of authority.
Portion of dike in Newark Bay, N. J.	Lehigh Valley Railroad Co.	For unloading material brought by water and used for filling in rear of dike.	Revocable license of Secretary of War issued to B. M. and J. F. Shanley.	July 17, 1890
100 feet of Dike No. 3, Raritan River, N. J.	Milton A. Edgar	Dock	Revocable license of Secretary of War	Mar. 1, 1895
Portions of dikes along the canal, South River, N. J.	Sayre & Fisher Co., and W. F. Fisher.	As bulkhead to retain filling and for loading and discharging vessels.	No authority on record	
Plot of ground at foot of 27th street W., Washington, D. C., pertaining to Potomac River improvement.	Littlefield, Alvord & Co.	Wharf and approaches	Revocable license of Secretary of War	May 1, 1893
Do	do	do	Lease from Secretary of War	Jan. 6, 1893
The same, at foot of 26th street W., Washington, D. C.	do	do	do	Nov. 1, 1893
Arkansas River, Ark.: Dike No. 2, at Little Rock	City of Little Rock	Roadway, with dump for city refuse at end of dike.	Revocable license of Secretary of War	Aug. 28, 1891
Dike No. 2, Pinebluff and Robroy Reach.	Pinebluff Water, Gas, and Electric Light Co.	As crib for intake pipe	do	Sept. 10, 1891
Land at Davis Island dam, Ohio River	The borough of Bellevue, Pa.	Maintenance of sewer underground.	do	May 20, 1899
Monongahela River improvement: About 75 feet of shore guide and fender crib below Lock No. 1.	J. M. Davis	Support for building	Articles of agreement with Monongahela Navigation Company; occupation existed at time of transfer of property to the United States.	
Abutment end of dam at Lock No. 1	Pittsburg, McKeesport and Youghiogheny R. R.	Right of way for three tracks.	No authority on record; occupation existed at time of transfer of property to the United States. Tracks were laid and new abutment built; harbor line has since been established at face of abutment.	
In office at Lock No. 2	Central District and Printing Telegraph Co.	Telephone service at expense of Pittsburg Coal Exchange.	Privilege existed at time of transfer of property to the General Government; United States has free use for official messages.	
Land at Lock No. 2	Pittsburg, McKeesport and Youghiogheny R. R.	Right of way for double tracks, one for about 600 feet and the other about 200 feet.	Occupation existed at time of transfer of property to the United States. It is thought that when the tracks were laid the company believed that the right of way had been legally acquired, but afterwards shown differently.	
At Lock No. 2	Baltimore and Ohio R. R. Co.	Water intake at forebay of lock and pipe leading therefrom across the lock land.	Permission of Monongahela Navigation Company; occupation existed at time of transfer of property to the United States.	
Do	East Pittsburg Water Co.	Water intake at forebay of lock and pipe leading therefrom across the lock land.	Permission of Monongahela Navigation Co.; occupation existed at time of transfer of property to the United States. Water company alleges a right to use a certain amount of water from the pool of the dam as derived from a right of water power for operating saw and grist mill reserved by its predecessor in the sale by the latter of land for the lock.	

At Lock No. 3	Pittsburg, McKeesport and Youghiogheny R. R.	Land for double track and station.	Permission of Monongahela Navigation Co.; occupation existed at time of transfer of property to the United States.	
Do	Mrs. Geo. W. Lutes (widow of former lock master).	Land for stable (16½ by 24 feet) and wagon shed (10½ by 20 feet).	Land otherwise unused; buildings were formerly nearer the lock and permitted in their first location by the Monongahela Navigation Co.	
At Lock No. 3	Central District and Printing Telegraph Co.	Telephone station in office and pole on lock land.	Revocable license of Secretary of War for maintenance of pole only; United States has special rates for official messages.	Nov. 18, 1898
In office at Lock No. 4	....do	Telephone pay station	Privilege existed at time of transfer of property to the General Government; United States has special rates for official messages.	
Herr Island lock and dam, Allegheny River, Pa.	Pittsburg Junction R. R. Co.	Space for single track across lock land.	Condition of right of way mentioned in title to land held by the United States. Investigation is being made by the United States district attorney as to the legal width of railroad right of way through lock land.	
Muskingum River improvement, Ohio:				
At Symmes Creek	Jasper K. McCann	Land for garden	Lease from Secretary of War; annual rental of $5	May 1, 1894
At Zanesvile	John T. Drone	Land and water power for flouring mill.	Lease from Secretary of War; annual rental of $153.60	May 1, 1890
Do	Baltimore and Ohio R. R. Co.	Land for drawbridge	Grant from State of Ohio	Feb. 28, 1853
Do	Edward Johnson	Land and water power for barley mill.	Lease from Secretary of War; annual rental of $361.74	May 1, 1890
Do	....do	Land and water power for flouring mill.	Lease from Secretary of War; annual rental of $413.82	May 1, 1889
Do	Muskingum Coffin Co	Land and water power for coffin factory.	Lease from Secretary of War; annual rental of $207.86	May 1, 1890
Do	Gary & McLaughlin	Land and water power for furniture factory.	Lease from Secretary of War; annual rental of $186.96	Do.
Do	Cincinnati and Muskingum Valley Rwy. Co.	Land for drawbridge	Grant from State of Ohio	June 4, 1879
Do	John Blankenbuhler	Land and water power for cracker factory.	Lease from Secretary of War; annual rental of $100	June 1, 1892
Do	Frederick Abel	Land and water power for flouring mill.	Lease from Secretary of War; annual rental of $184.50	Do.
Do	City of Zanesville	Sewer outlet	Grant from State of Ohio	Sept. 22, 1875
Do	Muskingum County	Land for drawbridge	....do	Mar. 26, 1884
Do	T. L. Moorehead	Land for warehouse	Lease from Secretary of War; annual rental of $25	May 1, 1893
Do	Muskingum and Ohio River Transportation Co.	....do	....do	Nov. 13, 1897
Do	The Great Southern Gas and Oil Co.	Land for pipe line across the river.	Revocable license of the Secretary of War	Nov. 8, 1898
Do	Zanesville Gaslight Co	....do	Grant from State of Ohio	
Do	City of Zanesville	....do	....do	
At Taylorsville	Muskingum County	Land for drawbridge	....do	May 6, 1884
At Malta	Zanesville and Ohio River Rwy. Co.	Land for railway track	No authority on record	
At McConnellsville	E. M. Stanbery	Land for mill site	Perpetual free lease from State of Ohio	Sept. —, 1839
Do	....do	Land for pipe line	Revocable license of Secretary of War	Oct. 3, 1895
Do	S. R. Dresser	....do	....do	Feb. 21, 1898

List of piers, wharves, and other structures or property pertaining to river and harbor works, etc.—Continued.

United States property occupied by private parties.	By whom occupied.	Purpose for which held.	Terms under which held.	Date of authority.
At Stockport	W. H. Phillips	Land and water power for flouring mill.	Lease from Secretary of War; annual rental of $230.04	May 1, 1889
At Beverly	Robbins Bros.	Land and water power for woolen mill.	Lease from Secretary of War; annual rental of $100	Do.
Do	Langenberg & Abrams	Land and water power for flouring mill.	Lease from Secretary of War; annual rental of $114.24	May 1, 1890
Do	Henry C. Baldwin	do	Lease from Secretary of War; annual rental of $100	Do.
Do	D. T. Brown	Land and water power for woolen mill, etc.	Lease from Secretary of War; annual rental of $109.80	May 1, 1890
Do	Isaac D. Spooner	Land and water power for planing mill, etc.	Lease from Secretary of War; annual rental of $100	Do.
At Lowell	E. W. Sprague	Land for warehouse	Lease from State of Ohio; annual rental of $5	Dec. 2 1879
Do	Rechsteiner Bros	Land for store yard	Lease from Secretary of War; annual rental of $10	Nov. 1, 1892
At Devols	Gates & Payne	Land and water power for flouring mill.	Lease from Secretary of War; annual rental of $168	May 1, 1889
At Marietta	Phœnix Mill Co	do	Lease from State of Ohio; annual rental of $350	May 1, 1873
Do	Baltimore and Ohio Southwestern R. R. Co.	Land for water station	Grant from State of Ohio; station to be removed when required.	Nov. 14, 1882
Do	do	Land for rest pier of bridge.	Grant from State of Ohio	July 18, 1851
At Lock No. 4, Kentucky River, Ky	Kentucky River Mills	Water power and land for mill and accessories.	99 year lease from State of Kentucky at an annual rental of $180; granted prior to date of transfer of property to the United States.	July 10, 1878
Kanawha River improvement, W. Va.:				
At Lock No. 3	Sheltering Arms Hospital	Land for steam pumps and pipe line.	Permission of Secretary of War	July 11, 1890
At Locks Nos. 2, 3, and 4	Kanawha and Michigan Rwy. Co.	Land for railway tracks	Instrument of approval executed by the Secretary of War under authority of act of Congress of February 28, 1887; rent free; company to maintain certain retaining walls, ditches, etc.	Nov. 5, 1892
At Lock No. 6	do	do	Act of Congress; quantity of land occupied is so small no compensation is exacted.	Feb. 28, 1887
Louisville and Portland Canal, Louisville, Ky.:				
North side, near Eighteenth Street Bridge.	Louisville Cement Co	Land for warehouse, chutes, etc.	Revocable license of Secretary of War; annual rental of $30.	Nov. 11, 1881
Do	Union Cement and Lime Co.	do	Revocable license of Secretary of War; annual rental of $5.	Do.
South side, at Fourteenth Street Basin.	Byrne & Speed	Land for coal elevator, coke oven, etc.	Act of Congress; annual rental of $250	Sept. 30, 1890
South wall, at or near Tenth street	Citizens' General Electric Co.	Intake pipe for boiler supply.	Permission of Secretary of War	Oct. 6, 1892
Near Kentucky and Indiana Bridge.	Marion County Distillery Co.	Land for pump and pipe line.	Revocable license of Secretary of War	Nov. 16, 1895
Do	do	Building and grounds inclosed by fence.	do	Nov. 20, 1895
Do	Kentucky and Indiana Bridge Co.	Land for south abutment of bridge and approaches.	Act of Congress	June 30, 1892

Do	do	For grounding electric wire by attaching plate at foot of canal wall, where it will be constantly under water.	Revocable license of Secretary of War; privilege not used at present.	Jan. 10, 1894
Green River, Ky.:				
Lock side at Lock No. 2	Livers & Welborn	Land and water power for two run of mill stone.	20-year lease from Secretary of War, with annual rental of $50 per run of stone; granted under provisions of the river and harbor act approved Sept. 19, 1890.	Jan. 28, 1892
Abutment end of dam at Lock No. 2.	R. C. Bryant	Water power	Verbal agreement from year to year; annual rental of $150.	
Abutment end of dam at Lock No. 3.	Craig Bros.	Land and water power	Verbal agreement from year to year; annual rental of $75.	
Abutment end of Dam No. 1, Barren River, Ky.:	William Boulton	do	Verbal agreement; annual rental of $150. To July 1, 1898, this occupation was under written lease from the Green and Barren Navigation Co., but question having arisen as to the ownership of land on which mill stands, authority was granted by Secretary of War to make verbal lease until question of title shall have been decided.	
6-acre tract of land at Grand Rapids, Wabash River, Ind.	Heirs of Joseph Hurd	Fenced in and built upon.	Without authority of the United States. This tract of land was deeded to the General Government by the Wabash Navigation Co., but the Hurd heirs have occupied it and set up a claim of title thereto. The matter has been brought to the attention of the Department of Justice, with request that the claim of occupants be examined into and that ejectment proceedings be instituted against the parties, if the title of the Government can be maintained.	
Portion of pier, Menominee Harbor, Wis. and Mich.	Menominee River Lumber Co.	As wharf and storage ground.	Lease from Secretary of War; annual rental of $1 on condition that the company keep that portion of the pier in repair.	Nov. 26, 1894
Land adjoining Sturgeon Bay and Lake Michigan Ship Canal, Wis.	Members of United States Life-Saving Service.	Six building lots for dwellings.	Leases from Secretary of War; annual rental of $1 for each lot.	Mar. 25, 1899
620 feet of pier at Ahnapee Harbor, Wis.	Ahnapee Dock Co	For loading and unloading freight.	Lease from Secretary of War; annual rental of $1 on condition that the company keep that portion of the pier in repair.	Nov. 15, 1898
Pier at Manitowoc Harbor, Wis	Chicago and Northwestern Rwy. Co.	To remove portion of pier and construct ferry slip and bulkhead.	Permission of Secretary of War, on condition that when slip is abandoned the pier is to be restored by the company.	May 5, 1896
Land at Waukegan Harbor, Ill	City of Waukegan	To build and maintain a dock.	Lease from Secretary of War; annual rental of $1	Sept. 4, 1897
Do	Cornelius Tamms	100 feet of harbor front	Lease from Secretary of War; annual rental of $100	Dec. 16, 1897
Fox River improvement, Wis.:				
Portage levee	Wisconsin Telephone Co	To maintain 12 poles	Permission of the Secretary of War; poles to be removed or changed in location when required by engineer officer in charge.	Oct. 20, 1898
Canal bank at Menasha	Chicago and Northwestern Rwy. Co.	Dock to replace pile trestle supporting tracks.	Permission of Secretary of War	Dec. 8, 1898
Dam at Menasha	Neenah and Menasha Water Power Co.	Use of flushboards	Revocable license of Secretary of War	July 10, 1899

List of piers, wharves, and other structures or property pertaining to river and harbor works, etc.—Continued.

United States property occupied by private parties.	By whom occupied.	Purpose for which held.	Terms under which held.	Date of authority.
Fox River improvement, Wis.—Cont'd.				
Works at Appleton	Green Bay and Mississippi Canal Co.	To increase water capacity of canal, protect canal bank, and build breakwater.	Revocable license of Secretary of War; bond given in sum of $10,000 to remove breakwater, or revet embankment, to prevent injury.	Aug. 2, 1898
Lower dam at Appleton	Manufacturing Investment Co.	Use of flushboards	Permission of Secretary of War	Jan. 15, 1894
Kimberly and upper Appleton dams	Kimberly & Clark Co	do	do	Dec. 10, 1895
Dam at Depere	Shattuck & Babcock Co	do	do	Jan. 27, 1897
Portions of north and south piers, Chicago Harbor, Ill.	Various riparian owners	Docks along Chicago River.	The portions of piers in question are now far inland and have been abandoned by the United States for fifteen or twenty years; are maintained by riparian owners; status should not be changed.	
At end of north pier, Chicago Harbor, Ill.	Dunham Towing and Wrecking Co.	Telephone station	Five-year lease from Secretary of War at nominal rate of $1 per annum; service is in aid of commerce and navigation.	Aug. 29, 1892
Pier at Calumet Harbor, Ill	Illinois Steel Co	Waste pipe leading through superstructure from company's mills.	No authority on record; built many years ago; is harmless, and should not be disturbed except for repairs.	
North pier, Calumet Harbor, Ill	do	Two water intake pipes	Permission from Secretary of War; pier will not be damaged by this work.	Jan. 7, 1899
Wing dam at entrance to Benton Harbor Canal, St. Joseph Harbor, Mich.	Cleveland, Cincinnati, Chicago and St. Louis R. R. Co.	Loading and unloading freight.	Act of Congress	July 13, 1892
199 feet of north revetment, Pentwater Harbor, Mich.	Sands & Maxwell Co	do	No authority on record	
Several hundred feet of south pier, Manistee Harbor, Mich.	Canfield & Wheeler Co	Wharf	do	
826 feet of north revetment, Manistee Harbor, Mich.	Manistee and Northeastern R. R. Co.	do	Revocable license of Secretary of War, granted on condition that company maintain the pier during occupancy.	May 31, 1893
52 feet of wing at inner end of south revetment, Charlevoix Harbor, Mich.	Lake Michigan and Lake Superior Transportation Co., and Northern Michigan Transportation Co.	do	No authority on record; occupation would seem to be merely an exercise of the right of easement.	
Piers and adjacent lands, Monroe Harbor, Mich.	John Dewey and others	Boathouses, bath houses, etc. (19 in all).	Without authority from General Government; papers in hands of Attorney-General for decision whether land in question is absolute property of the United States.	
Portion of east pier, Black River (Lorain) Harbor, Ohio.	Cleveland, Lorain and Wheeling R. R. Co.	For handling ore and freights.	Revocable license of Secretary of War, upon condition that United States vessels may use pier at all times for any necessary purpose.	May 14, 1895
Portion of east pier, Cleveland Harbor, Ohio.	The Pennsylvania Co. (Cleveland and Pittsburg R. R. Co.).	For receiving and shipping merchandise.	Agreement with Secretary of War, entered into under provisions of river and harbor act approved Aug. 14, 1876.	Feb. 17, 1877, and May 15, 1895.

Portion of east pier, Fairport Harbor, Ohio.	Consumers' Forwarding and Storage Co.	....do	Lease from Secretary of War, executed under provisions of river and harbor act of Aug. 11, 1888, and conditioned upon payment of annual rental of $2,000. Rent paid for one year, since which time all rental has been refused. For correspondence in explanation of this case see Annual Report of the Chief of Engineers for 1894, pp. 2415–2418.	June 22, 1889
North pier, Buffalo Harbor, N. Y	Delaware, Lackawanna and Western R. R. Co.	For handling and transshipment of coal.	Without authority; revocable license issued by Secretary of War Jan. 4, 1889, and revoked Feb. 20, 1891. Papers with Attorney-General with request for advice as to proper course to pursue to settle respective rights of the Government and the railroad company. For full history of case see Annual Reports of the Chief of Engineers for 1889, pp. 2373–2383, and for 1898, pp. 2774–2780.	
Portion of west pier, Charlotte Harbor, N. Y.	Otto P. Hiller	Boathouse	Temporary permission of Secretary of War	June 24, 1899
Do	F. H. Bettys	....do	....do	June 27, 1899
Do	August Fritz	....do	....do	June 29, 1899
Do	Julius Sellinger	....do	....do	Do.
Do	Gustave Frank	....do	....do	July 1, 1899
Do	Edw. F. Davison	....do	....do	Do.
Do	Dr. Sumner Hayward	....do	....do	July 21, 1899
Do	Wm. W. Miller	....do	....do	Do.
Do	E. W. Delano	....do	....do	Do.
Do	William Watters	....do	....do	Do.
Do	Chas. Fuller	....do	....do	July 27, 1899
Do	C. C. Sickles	....do	....do	July 29, 1899
Do	Henry W. Martens	....do	....do	Aug. 10, 1899

APPENDIX D D D.

EXTENSION AND MODIFICATION OF HARBOR LINES IN HONOLULU HARBOR, HAWAII.

DEPARTMENT OF STATE,
Washington, January 9, 1900.

SIR: Referring to my letter of the 23d ultimo, I have the honor to inclose herewith, for your information, a copy of a dispatch from the special agent of the United States at Honolulu reporting further on the proposed enlargement of the harbor of Honolulu.

I have the honor to be, sir, your obedient servant,

JOHN HAY.

The SECRETARY OF WAR.

[Second indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
January 15, 1900.

Respectfully returned to the Secretary of War.

The letter of the 23d ultimo from the Secretary of State on this subject, herein referred to, was returned to the War Department by my indorsement of January 3, 1900.

In that indorsement I suggested that the subject of the modification of the harbor lines in Honolulu Harbor be referred to a Board to be constituted by the commanding general of the Department of California, inasmuch as this department had no work in progress and no officers stationed at Honolulu and no way of obtaining the information upon which to base an intelligent recommendation.

JOHN M. WILSON,
*Brig. Gen., Chief of Engineers,
U. S. Army.*

[Third indorsement.]

WAR DEPARTMENT.
January 25, 1900.

Respectfully referred to the Adjutant-General, approved, as recommended by the Chief of Engineers.

Let the officers be selected from those serving in Hawaii.

By order of the Secretary of War.

JOHN C. SCOFIELD,
Chief Clerk.

[Fourth indorsement.]

HEADQUARTERS OF THE ARMY,
ADJUTANT-GENERAL'S OFFICE,
Washington, January 31, 1900.

Respectfully referred to the commanding general, Department of California, San Francisco, Cal., who will convene a Board of Officers

from among those serving in Hawaii for the purpose of considering the accompanying papers relative to the proposed extension and modification of the existing harbor lines at Honolulu, with a view to obtaining additional information upon which to base proper and intelligent action.

By command of Major-General Miles.

JOHN A. JOHNSTON,
Assistant Adjutant-General.

[Fifth indorsement.]

HEADQUARTERS DEPARTMENT OF CALIFORNIA,
San Francisco, Cal., February 9, 1900.

Respectfully referred to Maj. William Ennis, Sixth Artillery, for the information and guidance of the Board of Officers convened by paragraph 2, Special Orders, No. 28, current series, from these headquarters, of which he is the president.

Attention is called to copy of proceedings of original Board and copies of correspondence relating thereto, herewith inclosed, marked A and B.

By command of Major-General Shafter.

J. B. BABCOCK,
Assistant Adjutant-General.

[Sixth indorsement.]

CAMP McKINLEY,
Honolulu, March 30, 1900.

Respectfully returned to the adjutant-general, Department of California, with proceedings of the Board of Officers convened by paragraph 2, Special Orders 28, current series, Department of California.

WILLIAM ENNIS,
Major, Sixth Artillery, President of Board.

[Seventh indorsement.]

HEADQUARTERS DEPARTMENT OF CALIFORNIA,
San Francisco, Cal., April 11, 1900.

Respectfully returned to the Adjutant-General of the Army, inviting attention to the inclosed proceedings of the Board of Officers convened by paragraph 2, Special Orders, No. 28, current series, from these headquarters, which are approved by me.

WM. R. SHAFTER,
Major-General, Commanding.

[Eighth indorsement.]

ADJUTANT-GENERAL'S OFFICE,
Washington, April 18, 1900.

Respectfully returned to the Secretary of War, with proceedings of the Board of Officers, as directed in third indorsement.

H. C. CORBIN,
Adjutant-General.

[Tenth indorsement.]

OFFICE CHIEF OF ENGINEERS,
U. S. ARMY,
April 30, 1900.

Respectfully returned to the Secretary of War.

In the matter of the extension and modification of the existing harbor lines at Honolulu, brought to the attention of the War Department by the honorable Secretary of State by letter of December 23, 1899.

The previous action in the case will be seen by reference to the preceding indorsements hereon.

The lines at Honolulu were originally considered by a Board of Officers, which submitted a report[1] recommending certain lines described therein and delineated on a map accompanying the same. The lines recommended were not approved, but certain changes were made in the office of the Secretary of War, and the papers were returned to this office with a "memorandum description to substitute for the one in the report of the Board," on the back of which the approval of the Acting Secretary of War was indorsed under date of June 17, 1899.

The Board that has had under consideration the subject of the extension and modification of the lines submits a report which I have marked R, in red, for convenience of reference. On a map[2] herewith, also marked R, in red, are shown broken black lines, marked "Harbor lines of U. S. Govt.," which represent the existing lines; also broken black lines, marked "Proposed harbor lines," which are understood to represent the extension and modification recommended by the Board for approval.

I know of no objection to favorable consideration of the Board's views and recommendations in regard to the harbor lines.

The report of the Board also treats of certain matters regarding transfers of property between the Hawaiian Government and private parties.

A. MACKENZIE,
Acting Chief of Engineers.

[Eleventh indorsement.]

WAR DEPARTMENT,
May 4, 1900.

Respectfully returned to the Chief of Engineers.

The harbor lines at Honolulu proposed by the Board of Officers convened at Honolulu, Hawaiian Islands, pursuant to Special Orders, No. 28, to examine and report upon proposed extensions and modifications of existing harbor lines, are approved.

G. D. MEIKLEJOHN,
Acting Secretary of War.

LETTER OF MR. HAROLD M. SEWALL.

SPECIAL AGENCY OF THE UNITED STATES,
Honolulu, H. I., December 21, 1899.

SIR: With my dispatch No. 154 of December 8 I transmitted copy of a communication from the minister of foreign affairs, received just before the closing of the last mail, and exhibits setting forth a joint plan of the Hawaiian Government and the Oahu Railroad and Land Company for the enlargement of the wharf capacity of Honolulu Harbor.

In reference to this plan, I have the honor now to submit the following:

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[1] Printed in the Annual Report of the Chief of Engineers for 1898, p. 3769.
[2] Not printed.

1. The present harbor is entirely inadequate to the needs of the commerce of this port.

2. The permanent improvement of the harbor, which shall provide for future as well as present needs, is a work too seriously affecting our national and commercial needs and interests to be intrusted to the local government.

3. Until the Federal Government shall undertake this work, every encouragement should be given the Hawaiian authorities and corporations to provide temporary relief.

4. The joint plan submitted is well designed to this end. But that part of the plan transferring Government titles (now Federal titles) to tracts of land or water should be disapproved.

The Dowsett and Sumner tracts referred to is very extensive, and covers the whole reef and water front of the sea side of the harbor, including the quarantine station.

I respectfully request that a copy of this dispatch be sent to the honorable Secretary of War.

I have the honor to be, sir, your obedient servant,

HAROLD M. SEWALL.

Hon. JOHN HAY,
Secretary of State.

PROCEEDINGS OF A BOARD OF OFFICERS CONVENED AT HONOLULU, HAWAIIAN ISLANDS, PURSUANT TO THE FOLLOWING ORDER:

SPECIAL ORDERS, No. 28.

HEADQUARTERS OF CALIFORNIA,
San Francisco, Cal., February 8, 1900.

[Extract.]

* * * * * * *

2. Pursuant to instructions from the Headquarters of the Army, Adjutant-General's Office, of the 31st ultimo, a board of officers to consist of Maj. William Ennis, Sixth Artillery, Capt. Adam Slaker, Sixth Artillery, Second Lieut. G. R. Hancock, Sixth Artillery, is appointed to meet at Honolulu, H. I., as soon as practicable after the receipt of this order at that station, for the purpose of examining into and reporting upon the proposed extension and modification of the existing harbor lines at Honolulu, with a view to obtaining additional information upon which to base proper and intelligent action.

The junior member of the board will act as recorder.

* * * * * * *

By command of Major-General Shafter.

J. B. BABCOCK,
Assistant Adjutant-General.

HONOLULU, H. I., *March 28, 1900.*

The Board met pursuant to the above order at the palace in the city of Honolulu, H. I., at 2 p. m., February 20, 1900.

Present, all the members.

The Board consulted with Mr. Alexander Young, minister of the interior of the Hawaiian Government, and with him discussed the proposed extension of the harbor lines of Honolulu, and afterwards personally inspected the ground where the proposed docks and slips are to be built, and also those portions of Government land which it is proposed to transfer to the Oahu Railroad and Land Company, in

exchange for that portion of its property shown on the map and marked "C."

By a later mail the Board received the papers referring to the proposed transfer and improvements forwarded previously by the Hawaiian Government to the Government at Washington.

These consist of the following papers:

Report of the Langfitt Board, dated April 18, 1899, inclosed and marked "A."[1]

Letter of William A. Kinney, inclosed and marked "B."[1]

Correspondence[2] between B. F. Dillingham and the Hawaiian Government concerning exchange of lands in connection with the harbor improvements. Letter[2] of W. E. Rowell, superintendent of public works, dated October 18, 1899, and addressed to Mr. E. A. Mott-Smith, minister of foreign affairs, and letter[2] of Mr. E. A. Mott-Smith to Hon. S. B. Dole, president of the Hawaiian Islands. All of these latter communications being joined together and marked "C."

A map[2] of the north end of Honolulu Harbor, stamped on the back, "Office of the Adjutant-General, 307509, War Department." Letters of December 8[2] and December 21, 1899, from Hon. Harold M. Sewall to the Hon. John Hay, Secretary of State. Letters of the Hon. John Hay, dated December 23, 1899,[2] and January 9, 1900, to the Hon. Secretary of War, with indorsement thereon, marked respectively, "D," "E," "F," "G."

Other papers considered and inclosed are—

The joint letter[2] of merchants and bankers of Honolulu to Mr. Alexander Young, dated March 7, 1900, and marked "H."

The resolution[2] of the Honolulu Chamber of Commerce dated March 14, 1900, marked "I."

A map[2] showing to a greater extent than the one sent by the War Department the reef towards the light-house marked "L."

A paper[2] called "The Guide," relative to shipping in the port of Honolulu and marked "K."

A map[2] of the water grant to William Sumner and marked "M."

A deed[2] from Kamehameha III to William Sumner, with the opinion of Mr. E. P. Dole, relative to the right of the Hawaiian Government to Quarantine Island and the waters adjacent thereto, inclosed and marked "O."

The Board gave public notice of its intention and held sessions during five afternoons between 2 and 4, in the office of the depot quartermaster in Honolulu, and offered all persons interested an opportunity to give their opinion upon the proposed transfer and improvements.

Representatives of the railroad company and the secretary of the chamber of commerce were the only people who appeared before the Board.

After carefully considering the matter the Board is of the opinion that the proposed extension of docks in the harbor of Honolulu is the most expeditious method of relieving the present congested state of commerce in that port. The amount of commerce is shown in Exhibit K, wherein is stated the number of vessels now in port and on their way to it. The trade of Honolulu is constantly increasing, and when a cable is laid the number of vessels touching here will be greatly increased. The harbor of Honolulu is small and the shipping much

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[1] Printed in the Annual Report of the Chief of Engineers for 1899, p. 3769 et seq.
[2] Not printed.

crowded. The present wharf room is entirely inadequate, and ships have often to wait two weeks or more before being able to unload or ship their cargoes.

The Board has no hesitation in expressing its approval of the extension of Emmes, Sorrensons, Nuuanu, and Brewers wharves to the proposed harbor lines as shown on the map.

Nuuanu wharf was extended to that line before the report of the Langfitt Board was known here.

A large vessel lying at Sorrensons or Brewers wharf would extend beyond its head a distance nearly equal to the proposed extension, and would be able to unload only from her forward hatch, while, were the wharves extended, all her hatches could be utilized and no greater narrowing of the harbor would result.

The wharves extended would enable a large vessel or two smaller ones to find berths on either side and one at the head. The Board has carefully examined the space remaining in the harbor after the extension, and is of the opinion that there is plenty of room left for moving vessels up and down the harbor even while the present railroad wharf exists.

This opinion is confirmed by seafaring men with whom members of the Board have conversed. This space will be increased when the railroad wharf is removed, as it must be at an early date. To enlarge these slips by dredging into the land would involve great expense and necessitate the widening of Queen street, as shown in the letter of Mr. W. E. Rowell, superintendent of public works, in Exhibit C.

The proposed slips at the north end of the harbor will add at once 5,000 feet to the wharf facilities of this port, 3,000 of which will be under the control of the local government.

The thing to be considered is the exchange of land between the Oahu Railroad and Land Company and the Hawaiian government.

The tract, C, which the railroad company proposes to transfer contains 4.41 acres and is in great part under water at high tide. The tract marked A on the map was formerly a fish pond. It comprises 6.84 acres and has been filled in by the Hawaiian government. It will be very valuable for storehouses, and is very valuable to the railroad company for track and other facilities. The tract marked D, containing 3.15 acres, is a pond, and when filled in will also be a very valuable piece of property. The tract marked B contains 2.20 acres and is to a great extent filled in. It is a portion of the water grant obtained by William Sumner in 1840 from the Government of Kamehameha III.

This tract was purchased in 1890 by the Oahu Railroad and Land Company from the Dorsett and Sumner estate, and it is now in use by said railroad company.

The said railroad and land company has also leased certain rights in the remaining portion of the water grant to William Sumner. This water grant extends westerly along the reef to a point where a line drawn about northeast will pass a little to the west of Quarantine Island and continue until near the land, then southeasterly in an irregular line to the reef, and then south to the starting point.

This is shown in Exhibit M and also in the deed part of Exhibit O.

While the land portion of the grant to William Sumner is secure, it is claimed by the Hawaiian government that the grant of the water portion was only a fishing right, and does not prevent the government from building wharves or making other improvements upon it.

The claim of the Hawaiian government has been upheld by able lawyers, as shown in Exhibit O. The Board can assert from its study of the map of the grant that the words translated "one portion of dry land connected with said fishing ground is 240 fathoms long and 92 fathoms wide, and the tare ground is 120 fathoms long and 110 fathoms wide," are not descriptive of Quarantine Island, but do describe certain well-defined tracts on the land portion of the grant. On the other hand, the Hawaiian government paid rent for Quarantine Island for thirty years and left its rights in abeyance for sixty years. Not long ago it asserted its rights to Quarantine Island and its surrounding waters, and now holds possession of Quarantine Island.

Mr. Sewall is in error when he states that the tract to be ceded to the railroad company extends to the light-house. This tract B is a very small portion of the Sumner water grant, and embraces about 285 feet of water front and extends back therefrom about 700 feet, and in the proposed exchange of lands the railroad company asks the relinquishment of any claim thereto by the Hawaiian government. This tract is valuable and is suitable for docks for vessels. All the reef embraced in the Sumner grant is in shallow water and on it could be built wharves and docks.

The Board considers it pertinent to state here that before the recent establishment of the harbor lines, the Oahu Railroad and Land Company had no harbor rights on the southern portion of its land shown on the map. Before it could build its wharf or make any encroachment on the harbor it was compelled to lease from the Hawaiian government a strip of land or water 100 feet wide extending along the whole southern front of its holdings, including the tract B. This is shown on the map L. This strip was leased by the railroad company in 1890, and was so leased until the recently established harbor lines. This harbor line runs inside the 100-foot strip and along the land of the said company, thus giving them access to the harbor along all their southern border.

The railroad company is on this account prepared to ask for better terms in the transfer than would have been the case previous to the establishment of the harbor line. In regard to the public lands of the Hawaiian Islands the resolutions of annexation provide "that all revenue from, or proceeds of the same, except as regards such part thereof as may be used or occupied for the civil, military, or naval purposes of the United States, or may be assigned for the use of the local government, shall be used solely for the benefit of the inhabitants of the Hawaiian Islands for educational or other public purposes."

The Hawaiian government and the leading citizens of Honolulu have shown their desire to relinquish any benefits that may accrue to them from the tracts A, B, and D, in return for the wharves and slips they will receive in exchange.

In the face of such unanimous approval by the Hawaiian government and the citizens of Honolulu, the Board is not disposed to object to the proposed transfer.

As regards the tract B, and in view of the not remote opening of Pearl Harbor, it is a question whether the United States Government needs this property for its own use; and if not, whether it be willing to relinquish its rights to it, whatever they may be, in favor of the Oahu Railroad and Land Company.

It may be that the railroad company has the advantage in money

value in this exchange, but on the other hand should it refuse to make the transfer unless the portion B is included, the proposed new docks and wharves are not likely to be built, and a very much-needed harbor improvement will be indefinitely postponed.

The present harbor line in Youmans slip into which the Nuuanu River flows, while it cuts off the railroad company's lands from rights on that portion of the harbor, apparently prevents that very suitable location for a dock from being used by anyone for that purpose.

After the proceedings had been written this far, a copy of the deed of J. K. Sumner and J. I. Dorsett to the Oahu Railroad and Land Company was sent to the Board by Mr. Hatch. The deed[1] is inclosed and marked "P."

There being no further business, the Board adjourned sine die.

William Ennis,
Major, Sixth Artillery, President.
A. Slaker,
Captain, Sixth Artillery, Member.
Gwynn R. Hancock,
Second Lieutenant, Sixth Artillery, Recorder.

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[1] Not printed.

APPENDIX E E E.

REPORT OF BOARD OF ENGINEERS ON HOUSE BILL NO. 1065, FIFTY-SIXTH CONGRESS, FIRST SESSION, "TO AUTHORIZE THE CONSTRUCTION OF BRIDGES ACROSS THE OHIO, MONONGAHELA, MISSISSIPPI, KANAWHA, TENNESSEE, CUMBERLAND, AND ILLINOIS RIVERS, AND TO PRESCRIBE THE DIMENSIONS OF THE SAME."

ENGINEER OFFICE, UNITED STATES ARMY,
Cincinnati, Ohio, February 23, 1900.

GENERAL: The Board of Officers of the Corps of Engineers, constituted by Special Orders, No. 7, Headquarters Corps of Engineers, United States Army, Washington, February 3, 1900, to consider and report upon House bill 1065, Fifty-sixth Congress, first session, "to authorize the construction of bridges across the Ohio, Monongahela, Mississippi, Great Kanawha, Tennessee, Cumberland, and Illinois rivers, and to prescribe the dimensions of the same," has the honor to submit the following report:

The Board met at Cincinnati, Ohio, on February 21, 1900, pursuant to the above-mentioned order and the call of the senior member, and remained in session to and including February 23, 1900, when it adjourned without day, having completed its action upon the matter before it.

The legislation proposed in House bill 1065, Fifty-sixth Congress, is a general bridge law covering the Mississippi River and all its more important tributaries above Memphis except the Missouri. Legislation of this character and scope is of paramount importance to the navigation interests and of almost equal moment to cross-river transportation. The decision at each point where the two interests meet must rest upon a reasonable compromise between them. Every bridge that has piers in water of navigable depth, or superstructure of height less than that of the vessels seeking to pass it, is a greater or less obstruction to navigation and materially affects its interests. Bridge piers in navigable water are a menace to navigation of such magnitude that, if natural obstructions, their removal would be called for and insisted upon. So well recognized is this fact that the maximum practical length of spans should be required if necessary to reduce such obstructions within reasonable limits or to a minimum. In specific instances the Government has refused to permit the construction of a single pier within the navigable limits, even when it was known that such refusal would probably make the cost and difficulties of construction prohibitive. The questions at issue between the two interests are invariably on one side the creation of a material and permanent obstruction to navigation, the full effect of which can seldom be predicted with certainty, and on the other, an increase in the cost of bridge construction. It is the opinion of this Board that an increase in the cost of bridge superstructure should not be permitted to outweigh a need-

less obstruction to navigation, but that, within practicable limits, such obstructions should be reduced to the minimum by requiring such length of spans and such reduction in the number of piers as may be necessary to accomplish the desired end and as may be practicable in the present condition of the art of bridge building. The action of the Board is based upon these principles.

The question before the Board has been the subject of much discussion and investigation for many years. Upon the Ohio River it has resulted in the regulation of the construction of bridges by a general act that is understood to operate satisfactorily. A like result has been obtained upon the Kanawha River. Other general acts have been proposed, and in 1888 a Board of Officers of the Corps of Engineers carefully considered and prepared a general bill relating to the Mississippi, Missouri, and Illinois rivers. The bill and report of the Board of 1888 will be found in the Annual Report of the Chief of Engineers, United States Army, for 1888, pages 2371 et seq., and full use of them has been made by the present Board in its deliberations and recommendations. With a full knowledge of present requirements as indicated by actual or proposed special and general legislation, and by investigations and reports thereon, together with the special experience of its individual members, the Board has not deemed it necessary in this instance to enter into an open discussion of the subject by public hearings or otherwise.

The bill referred to the Board for its consideration and report is considered unnecessarily exacting in some particulars and is found to be so incomplete in many details and general requirements that no attempt has been made to amend it. A new draft covering the rivers mentioned in House bill 1065, with the addition of the Allegheny River and the Mississippi River from the mouth of Minnesota River to the mouth of the Missouri River, has been prepared. The bill prepared by the Board of 1888 has been used as a basis and such changes have been made therein as appear desirable to the present Board. This new draft is attached hereto as a part of this report.

The Board is unanimous in its views as to the essential points that should be incorporated in a general bridge law covering the rivers under consideration, and has embodied these views in the new draft presented herewith. Should the enactment of general legislation authorizing and regulating the construction of bridges over the rivers mentioned be deemed desirable and in the interest of navigation, the Board recommends that its own draft be substituted for House bill 1065, Fifty-sixth Congress, and that it receive favorable consideration.

For a full explanation of the present Board's draft it will be considered and its requirements and restrictions noted by sections. The sections referred to are those of the present Board's draft, excepting that when placed in parentheses they must be understood to refer to the draft of the Board of 1888. The bill under amendment is that of the latter Board as found in the Annual Report of the Chief of Engineers, United States Army, for 1888, pages 2384 et seq. Liberal quotations have been made from the report of the Board of 1888 in explanation of the details of the bill, and full acknowledgment is here made for such extracts as are not specifically acknowledged hereafter.

Title.—The word "regulate" has been substituted for the word "prescribe" so that the last clause shall read "and to regulate the location, dimensions, and character of the same." The title has also

been rewritten to cover the rivers provided for in House bill 1065, Fifty-sixth Congress, and to include the Allegheny River and the Mississippi River above the mouth of the Missouri River.

Section 1.—The construction of bridges is authorized only "when public necessity so demands." The Board considers that all bridges, no matter how carefully located or planned, are greater or less obstructions to navigation, and while it is doubtless proper that the latter interest should give way to a certain extent when a bridge *is* a public necessity, yet it does not seem right that this hardship should be imposed unless the general interests imperatively require it. This consideration is of especial importance in case of the duplication of bridges at any locality. It is a known fact that in several cases the construction of bridges has been contemplated where such construction was not a public necessity, and where the additional obstruction to the interests of navigation would have been serious, without any compensating advantage to the general public.

Bridges may be constructed only "at points where said construction will not unreasonably obstruct navigation." "Unreasonably obstruct" has been substituted for "materially affect." This clause, without the just mentioned substitution, is found in all the recent bridge acts for the Upper Mississippi River, and is an important one. There are some points where the construction of a bridge would be almost a bar to successful navigation, whereas at other points in the vicinity a bridge would not be so serious an obstruction as to prohibit its construction. In such cases it seems proper that the authority to construct shall only apply to the localities where regard for the navigation interest will best justify the construction.

"And hereafter no bridges shall be built over said rivers within said limits except under said provisions and requirements." Acts, general or special, have authorized the construction of bridges within the limits contemplated by this act. The general acts and some of the special acts that set no time limit as to their operation are still in force. The United States has heretofore assumed jurisdiction of bridges within the proposed limits by prohibitive or permissive general legislation, but the rules to be enforced within these limits should be applied to all bridges hereafter constructed, independent of the particular source from which the permission to construct is derived. This point is also provided for elsewhere in the proposed act in different forms.

Section 2 relates only to the form of the act, and only such amendments have been made as are necessary to meet the changes in the limits and the general form of the act below.

Section 3.—Some few changes and additions have been made in the definitions of terms of frequent occurrence in the act. Throughout the act as now submitted many minor changes of wording have been made to obtain uniformity of phraseology and to meet the changes made in this section.

Section 4 contains the general provisions relating to the height and location of spans of high bridges. The last clause has been reworded so as to require that where the channel is variable the number of channel spans shall be so increased that there may be such a span available for any position of the channel. In many portions of the rivers covered by this act, particularly in that portion of the Mississippi River below the mouth of the Missouri, the channel has no fixed position, but from time to time may be found at any point within the

banks of the stream. Should a bridge be built at such a locality, it should be required to have such a number of channel spans that one span of the full width required by this act will be available for navigation at any and all times. Otherwise, a change in the location of the channel might cause a bridge to become more obstructive to navigation than is intended by this act to be permitted.

Section 5 contains the general provisions relating to low bridges and to the drawspans and openings of such bridges in the same general form as recommended by the Board of 1888. The general principles governing the location of channel and drawspans are laid down, but no attempt is made to prescribe any particular design or mode of operation for drawspans. It is sufficient for navigation purposes to know that an opening or openings of the prescribed width will be available when required for the passage of river craft, and the method of effecting such openings should be left, as far as possible, to the judgment of the builders of the bridge, subject to the revision provided for in this act.

The amended section also requires that draw openings shall, if practicable, be visible for a distance of not less than 1 mile above the bridge. Safety requires that descending boats or other craft should be able to know certainly whether the draw is open or shut a sufficient time before reaching it to admit of stopping or landing, should either be necessary.

The other provisions of section 5 of the 1888 act have general application to both high and low bridges and are transferred to sections 7 and 8.

Section 6 of the act of 1888 Board relating to the operation and opening of drawspans is omitted. Its subject-matter is fully covered by general legislation enacted since 1888.

Section 6 corresponds to section 7 of the 1888 Board. The latter has been amended by providing that the evils therein prohibited shall be corrected by existing general law, the date of which is subsequent to 1888. It relates to the alignment of bridges and bridge piers and prohibits the creation of obstructions intended to secure faulty foundations. The axes of bridges are required, as nearly as practicable, to be at right angles to the current. This is deemed important in order to prevent the construction of bridges that are very oblique to the direction of the current and that are not considered safe for navigation. The prohibition of riprap in channel or drawspans is extended to all spans. Experience has shown that its use is never necessary except as a remedy for improper construction, and its presence always affects the waterway and may unduly increase the velocity of the current at the site of the bridge. This section also requires the removal of this and all other obstructions, under the Secretary of War's direction, by and at the expense of the company or persons owning, controlling, or operating the bridge.

Section 7 corresponds to section 8 of the 1888 act with the addition of the last clause from section 5 of that act. The first clause is intended to regulate the character of the approaches and other parts of the bridge with special reference to their bearing upon the flood discharge of the river.

The last clause of the section provides that in certain cases where the use of the river bank for wharf or other purposes might obstruct the passage through or under the bridge, the right to such use of the bank

shall be extinguished by the owner of the bridge. The distance over which this right shall be extinguished above and below the bridge is increased from 700 feet to 1,000 feet, and made more flexible by adding a minimum limit of 500 feet. This provision is not a new one, occurring in the general bridge law for the Ohio River, and in other laws, and the Board deems it desirable and proper, particularly in case of low bridges for which a shore location of the draw openings is exacted wherever practicable. Provision is added to the 1888 act for anticipating such obstruction by requiring, as an alternative to the extinguishment of the rights just mentioned, an increased length of span. This alternative will usually be applicable previous to construction only, and to high bridges, but it recognizes the fact that at certain sites local conditions require longer spans, as has been held in many special instances.

Section 9 of the 1888 act is omitted. The end sought to be attained by it is provided for by the general authority conferred in section 20 relating to the approval of bridge plans.

Section 8 corresponds to section 10 of the 1888 act, with the addition of a clause from section 5 of the same act. The first clause is transferred from the latter act with only minor verbal amendments, excepting that the enforcement of the provisions of the section is to be made in accordance with existing law. The owners of bridges are required to construct and maintain such accessory works as may be necessary to overcome, to as great a degree as possible, the obstruction to navigation caused by construction and maintenance of bridges.

It is also required that, so far as practicable and when in the interests of navigation, all bridges should be located above important landings. The reason for this lies in the fact that with a bridge located just below a landing boats coming to or leaving the same would be in greater danger of being injured.

Provision is made for such accessory works as may be necessary to facilitate the passage of channel of raft spans or draw openings of less than 300 feet clear channel way. In order that sheer booms may be required and permitted at locations where they could be used more advantageously than protection piers, they are named among the accessory works that may be required by the Secretary of War.

Section 9 prescribes the general dimensions of bridges over the Ohio River, and except as to length of spans no material change is made in the existing general law. House bill 1065 requires that all bridges erected across the Ohio River shall have a channel span of not less than 1,000 feet clear channel way. Near Cairo the channel of the Ohio is much wider and less permanent in location than near Pittsburg, and nearly all coal tows, after being broken up to pass through the canal at Louisville, are remade with much increased widths and lengths. A clear channel way of 1,000 feet appears to the Board to be necessary below Louisville, but the difference in conditions above the canal is such that from Pittsburg to Louisville a channel way of 800 feet seems sufficient and equivalent to 1,000 feet below. A greater width would impose an unnecessary burden upon bridge owners.

The height of channel spans above high and low water is retained as in House bill 1065 and the existing general bridge law for the Ohio River, but the stages from which these heights are to be determined are specified as the low water of 1881 and the high water of 1832. High water of 1832 (64.3 feet above low water at Cincinnati, Ohio) is

2.1 feet lower than that of 1883 and 7.4 feet lower than that of 1884, but is above any other high water of the past sixty-eight years. It is considered to be sufficiently high for use in determining the elevation of bridges, particularly in view of the fact that higher stages continue but a short time during which all navigation is practically suspended.

It hardly appears necessary, in view of the well-known facts relating to Ohio River navigation interests, to enter upon an extended discussion of the reasons governing the Board's recommendation as to lengths of channel spans. The increase in the size of Ohio River coal tows to 40 boats, carrying 1,000,000 bushels of coal and having a width of 280 feet and a length of 1,100 feet, justifies the wider spans proposed in the Board's draft.

These spans are much longer than the minimum spans authorized by existing law, but a material increase over the latter has been exacted in many specific instances and the spans recommended are practical of construction. In order to compete with the modern economies of land transportation, bulk freight must be moved by water in large volumes without breaking cargo and with the least practicable interruption. The Board sees many reasons for encouraging such transportation, but none for curtailing it. Every additional bridge of limited span increases the obstruction and cost of such transportation, and the facilities of bridge builders should be exerted to the utmost if necessary to reduce such obstructions to the minimum, notwithstanding an increased cost to bridge owners.

It may be remarked here, as applicable to the Ohio River and the other rivers intended to be covered by this act, that the Board recognizes the difficulties encountered in so prescribing by general legislation the dimensions of bridges over rivers of great length and variable regimen as to exact the full requirements of navigation at unfavorable localities without imposing upon bridge owners an undue hardship at points where the conditions would reasonably permit of smaller dimensions. The Board has deemed it advisable to incorporate in this act what, in its opinion, should be the minimum requirements at such points as would ordinarily be selected for bridge sites and to insist that these requirements shall be met unless the local conditions at the actual site are such that, in the opinion of the Board of Engineers provided in section 20, a reduction therein may be made without injury to the interests of navigation.

Section 10.—House bill 1065 requires all bridges over the Monongahela River to have a channel span with a clear waterway of not less than 800 feet. The Board has reduced this to 500 feet. The width of a large portion of the river at navigable stages is less than 800 feet, and recent acts of Congress have prescribed channel spans of but 500 feet minimum clear width. This latter width has not been found to be insufficient for ordinary conditions, and was selected by the Board in the belief that in special localities, near the mouth of the river or of a navigable tributary, the Board of Engineers provided in section 20 would recommend such increased width of channel span as the local circumstances might require.

Section 11.—The Board has added a section covering the Allegheny River, upon the request of parties interested in the proposed legislation. This river is an important tributary of the Ohio, as are four other rivers named in this act. The United States has entered upon its improvement by locks and dams, and a large increase in its com-

merce is expected. A least width of clear channel way of 400 feet is required from the mouth upstream, about 161 miles, to Hickory Creek, the head of large rafting and towage transportation, and a least width of 250 feet is deemed sufficient above that point. The extreme lower part of the river can be used as a harbor, especially during Monongahela River floods, by the largest craft that come to Pittsburg and now enter the latter river for a short distance. It is practicable to extend the Allegheny River harbor only to Sixth street, Pittsburg (0.5 mile from the mouth), and consequently a bridge height of 73 feet, that of the existing modern and substantial bridge at the mouth of the Monongahela River, is required from the mouth to Sixth street only. Oil City is the probable upstream limit of medium-sized packet navigation requiring a clear headroom of 50 feet. Above Oil City the river banks are generally lower and the floods of less height. For that section of the river a clear headroom of 40 feet is deemed sufficient and practicable.

Section 12.—The legislation proposed by the Board for the Kanawha River is in substantial agreement with the existing general law (act approved March 3, 1887) regulating the construction of bridges over that river. The reasons upon which this law was based are set forth in the report of the Board that drafted it (Annual Report Chief of Engineers, 1884, pp. 1797 et seq.), and need no repetition here. The law as it now exists, and as it is proposed in the draft of the present Board, is better and more carefully drawn in several respects than in House bill 1065.

The clear channel way has been reduced from 500 feet (House bill 1065) to 400 feet, as provided by existing law. Four hundred feet clear width is sufficient, and 500 feet is an excessive requirement. The clear headroom is required to be measured from low water and high water, instead of from "pool full," as in House bill 1065. The measurement from the pool stage is not adapted to a river with movable dams. The height of bridges should be governed by navigation in high and medium stages when the dams are down and the river has practically its natural elevation and slope. With the plane of reference proposed by House bill 1065, two bridges, located one above and the other below a dam, might be close to each other and yet differ in headroom at open-river stage by an amount almost equal to the lift of the dam. Furthermore, the measurement from pool stage excludes from the operation of the law that part of the river lying downstream from the lowest dam, which part is important and is already spanned by a railroad bridge.

The act proposed by this Board requires the axes of bridges over the Kanawha to be at right angles to the current at high-towing stage. This provision is not found in House bill 1065 and needs no explanation other than a consideration of the character of the transportation interests on this river. It is also required that all spans shall be through spans. This is in accordance with existing law, and is important for the reasons stated in the report of the board that drafted that law. (Annual Report, Chief of Engineers, 1884, p. 1807.)

The general provisions of the act prepared by the Board affect the Kanawha River as they do all the other rivers mentioned therein. It is well to mention, however, that the right of way for telephone purposes, which the Board has introduced into the general requirements, is of great importance on the Kanawha River, where the two existing bridges carry Government telephone lines.

The existing law regulating bridges over the Kanawha River

refers in its title to the river below the falls, although the limiting words "below the falls" are omitted from the body of the act. As any bridges to be built over the portion of the river above the falls, which portion is only about 2 miles long, would be under the control of the Secretary of War by the river and harbor act of March 3, 1897, even if considered as not included in the Board's act, there seems to be no object in omitting specific mention of them, as was done in the existing law.

Section 13.—In the sections relating to the Ohio, Monongahela, and Allegheny rivers provision is made that all bridges over those streams shall be high bridges. On the Cumberland River the requirements for reasonably free navigation are not as great as on the rivers just mentioned, and at some points where the banks are low, a requirement (as in House bill 1065) that only a high bridge should be built, with a clear head room of 100 feet at low water, would be onerous by reason of the cost of the approaches to such a bridge. Either high or low bridges are proposed to be authorized over this river. The Board considers a requirement that all high bridges over the Cumberland River shall have channel spans with a minimum clear width of 250 feet and clear head room of 100 feet at low water, as proposed in House bill 1065, to be reasonable and a sufficient protection to the interests of navigation. Such bridges would have clear channel ways equal to, and head room 3 feet greater than, the best existing bridges.

Low bridges are authorized with draw openings having clear channel ways not less than 175 feet and clear head room not less than 6 feet at high water. The same remark as to the reasonableness and sufficiency of the requirements for high bridges applies to those for low bridges.

Section 14.—House bill 1065 proposes to permit only high bridges over the Tennessee River. To the remarks just made upon this same restriction as to the Cumberland River, may be added that the banks of the Tennessee River and the approaches thereto are so varied in character that it would be impracticable, or at least disadvantageous to the general public interests, to limit the construction of bridges to any one type. The existing bridges are about equally divided between the high and low types. The character of the river is such as to render admissible above Chattanooga a more moderate width of span than is called for by the conditions existing below that point. The dimensions recommended by the Board are, in its opinion, the minimum admissible reasonably to accommodate the present and prospective commerce upon a river of the size and character of the Tennessee River.

In the title and section 1 of House bill 1065, reference is made to the Mississippi River, without limit, but in section 3, relating to the special requirements for bridges over that river, provision is made only for that part below the mouth of the Missouri. The Board considers it wise to include in such an act the upper Mississippi River, and in its draft has therefore extended the limits of this act to the mouth of the Minnesota above St. Paul, as in the act of the 1888 Board. The physical characteristics and the requirements of navigation vary largely throughout the length of the Mississippi, and, for the purposes of this act, the river is divided into five parts which are considered in sections 15, 16, 17, 18, and 19.

The Board has placed the southern limit of this act at Natchez, Miss. This is the limit found in the act considered by the 1888 Board and is here adopted, although it must be said that no particular reason exists for fixing it at this precise point. So far as concerns the river inter-

ests the provisions of the act might be extended to New Orleans. At New Orleans ocean shipping is met, and the conditions change. Having in view the difficulties of bridging the lower river, and the various circumstances of the case, the Board has somewhat arbitrarily set the limit at Natchez, believing that when a bridge is built below that point or another point not far downstream from it, the case should be a special one and be considered according to the conditions existing at the time of construction.

Section 15.—The general conditions of navigation and the general character of the boats to be accommodated are similar for the Upper Mississippi and Illinois rivers at the present time, and the requirements for bridge construction would seem to be identical in their general sense, with minor variations as to details. These two rivers, with the Des Plaines River, a part of the Illinois River system, are therefore provided for in the same section. Over the Upper Mississippi, high, low, and ponton bridges are authorized, but over the Illinois and Des Plaines rivers only low and ponton bridges. There is at the present time no objection to high bridges over the last two rivers, of the type and height permitted on the Upper Mississippi, but, having in view the possibility of the opening of deep-water navigation from the Lakes to the Mississippi, as much discussed in connection with the Chicago Drainage Canal, the Board deems it advisable to restrict the use of bridges of a limited height and permit the construction only of bridges with draw openings. Such a requirement will meet the needs of navigation and inflict no hardship on bridge owners, if the number of low bridges over these rivers may be used as a criterion. This principle is not extended to the Mississippi below the mouth of the Missouri. For reasons stated hereafter, low bridges are held not to be permissible on that section of the river and the probability of deep-water navigation is not considered sufficiently imminent to warrant increasing at present the height of bridges over that necessary to meet existing requirements.

The proposed lengths and heights of spans for high and low bridges over the Upper Mississippi and for low bridges over the Illinois and Des Plaines rivers are the same as recommended by the 1888 Board and as found in recent special acts. The provisions governing pile and ponton bridges are similar to those recommended by the latter Board, and to those governing the construction of existing bridges of this type. It does not appear necessary to enter into a discussion of the reasons upon which these recommendations are based. They will be found stated in full in the report of the Board of 1888. (Annual Report, Chief of Engineers, 1888, p. 2378.)

The Board is of the opinion that low or draw bridges are entirely inadmissible on the Mississippi below the mouth of the Missouri. This view has been consistently held by various Boards of Engineer Officers and by the Mississippi River Commission and the officers in charge of the improvement of the river.

The reasons for this opinion have been so fully stated that the Board will not repeat them except as found in previous reports.

The Board of Engineer Officers that considered in 1886 the character of the bridge then contemplated at St. Louis expressed its views as follows:

* * * From evidence before it the Board is decidedly of the opinion that the increased cost, if any, of a high bridge over that of a low bridge, including erection

and operation, has not been shown to be so great as to warrant the conclusion that a low bridge is more desirable than a high bridge, even on the ground of cost alone.

The Board has reason to believe that if a drawbridge were built it is probable that the channel might at times leave the drawspan and thus make the bridge impassable.

The Board calls attention to the fact that an essential feature of the plan of a low bridge is that the channel should be held through the drawspans. It is not certain that this can be done at all; certainly not without great cost. * * *

The Board is decidedly of the opinion that a low bridge with a draw in it should not be authorized or allowed below the mouth of the Missouri River. Such a structure would be a serious and grave obstruction to navigation and a direct and oppressive tax upon all river interests. Justice to navigation interests requires that the proposed bridge should be no greater tax upon the commerce of the river than is absolutely necessary. * * *

The Board desires to emphasize the difference of the Mississippi River above and below the mouth of the Missouri River. Above, it is a quiet river, comparatively free from sediment and drift; the oscillation between high and low water does not exceed about 22 feet. Although low bridges on such a stream are obstructions to navigation, they are not intolerably so. Below the mouth of the Missouri all this is changed. The rise and fall increases to 42 feet at St. Louis and over 50 feet at Cairo, the current doubles in velocity, as shown in the table in our first day's proceedings; the volume of sediment is vastly increased; drift frequently runs; the bed is constantly shifting. In a word, the river entirely changes its character, and low bridges must be regarded as an intolerable nuisance to navigation interests.

The Ohio River, which in its lower course resembles the Lower Mississippi, is protected by a general bridge law forbidding the construction of low bridges, and, in the judgment of the Board, such a law, properly adapted to suit the requirements of the Mississippi below the mouth of the Missouri River, would be useful legislation, in view of the increasing demand for bridges on the Lower Mississippi. (Annual Report, Chief of Engineers, 1887, pp. 2640–1.)

The Board of 1888 states its opinion as follows with regard to the drawbridges over the Missouri, and applies the same reasons to the Lower Mississippi:

The Board have omitted the provisions for drawbridges, as they consider that such structures, dangerous and undersirable in all cases, are entirely inadmissible on the Missouri, where the shifting channels and fierce current require that all possible precautions be taken to prevent bridges from becoming an absolute bar to navigation. This view has been consistently held and urged by the officers in charge of the improvement of this river, and also by the Missouri River Commission. The Board holds that all spans over the waterway should be available for the passage of boats when necessary or desirable, and that these spans should be as long as possible, both for the safety of navigation and for the free discharge of the river at high stages. These conditions cannot be complied with in a low bridge. Out of seventeen, the total number of bridges either built or building over the Missouri, but four are low bridges, and all these were constructed prior to 1875. All four are difficult and dangerous of passage, two, in fact, being well-nigh impassable at high stages, while at the two others navigation has been several times entirely suspended, owing to the shifting of the channel from under the drawspans at low water. Since their construction, ten other bridges have been built, all high, although the alternative of a low bridge was allowed. The motive for this is said to have been economy. It would seem, therefore, altogether unjustifiable to authorize a class of bridges which, if built, would be a constant menace to navigation and which seem to be rarely demanded, even on the score of economy. (Annual Report, Chief of Engineers, 1888, p. 2378.)

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The next four sections pertain to the Mississippi below the mouth of the Missouri, over which there is as yet but one bridge, that at St. Louis. The corresponding sections of the original bill allowed drawbridges to within 8 miles of the St. Louis bridge, and below St. Louis drawspans in all high bridges are required. These features do not meet with the approval of the Board, and are omitted from the proposed substitutes for these sections. The Mississippi below the junction of the Missouri partakes mainly of the characteristics of that stream, with the additional feature of greatly increased volume. Instead of the gentle current and comparatively fixed channels of the Upper Mississippi and Illinois, we find an impetuous current and great instability of channel. Hence, all the objections urged against drawbridges on the Missouri apply with equal force here—greater, in fact, because the navigation interests are more extensive, great rafts and tows must be provided for, and below St. Louis the

boats employed are much larger. The report of the Board which examined into the question of a bridge recently proposed above the Eads Bridge at St. Louis (Senate Ex. Doc. No. 20, Forty-ninth Congress, second session) gives at length the reasons why low bridges between the mouth of the Missouri and the Eads Bridge are considered inadmissible, and in this conclusion the present Board fully concur. The draws called for in high bridges below the Eads Bridge the Board consider highly objectionable. Their only object, apparently, would be to enable boats having tall chimneys to get through the bridge without lowering them, at times when the stage of water would not admit of their passing under the fixed spans. But it is only at high stages that any inconvenience from this source would be experienced, and at such times the strong current would render the passage of a heavily-laden boat through a narrow draw opening an extremely hazardous if not impracticable operation. On the other hand, the extra cost entailed upon the construction of the bridge by additional piers and expensive drawspans would be a heavy and very distasteful item. Therefore, as they consider that the value of these drawspans to navigation would be little or nothing and the extra cost entailed by their construction unnecessary, they have recommended their omission from the requirements. The Board feel well assured that, by the use of well-known appliances, the upper portions of steamboat chimneys can be lowered to the level of the pilot houses, and as the clear headroom they have recommended will pass the pilot houses of the largest boats on the river, they consider that the slight delay which may accompany this operation of lowering the chimneys will be far less onerous to navigation than the great danger and difficulty which must, of necessity, attend an attempt to pass through a narrow draw opening at high stages of water. (Annual Report, Chief of Engineers, 1888, p. 2379.)

The conditions existing on the Mississippi River below the mouth of the Missouri vary so widely that the Board has considered it by sections, as follows: (1) From the mouth of the Missouri to the northern limit of the city of St. Louis; (2) from the northern limit of the city of St. Louis to the Eads Bridge; (3) from the Eads Bridge to the mouth of the Ohio; (4) from the mouth of the Ohio to Natchez, Miss.

Section 16 relates to the Mississippi River from the mouth of the Missouri to the northern limit of St. Louis. Channel spans of not less than 500 feet, with side spans not less than 400 feet and headroom not less than 55 feet, are required, as in the bill of the Board of 1888. A height of 75 feet, as provided in House bill 1065, is regarded as excessive. (Annual Report, Chief of Engineers, 1888, p. 2379.)

Section 17 covers the harbor of St. Louis above the Eads Bridge, and its requirements are the same as found in the 1888 bill. The improvement of St. Louis Harbor contemplates the reduction of the width of the river to 1,500 feet. Over this portion of the river should be required spans that will have clear widths at least equivalent to those of the existing Eads and Merchants bridges, and a headroom of 55 feet, as provided for the upper river bridges. Any additional spans required to cross the remainder of the existing river bed may have a less width and height. The next following section makes provision for bridges at any point in St. Louis Harbor, and nearer than 1 mile to existing bridges.

Section 18.—The Eads Bridge at St. Louis is, by reason of its character, the upstream limit of lower river navigation. Below that bridge provision must be made for the larger boats and the grain tows that navigate from St. Louis south. The Board has followed the dimensions recommended by the 1888 Board and quotes from the report of the latter Board the reasons on which these dimensions are based:

* * * The Board consider that 500 feet is the least width allowable for any span over the waterway, and that a clear headroom of 65 feet above high-water mark is needed to pass the pilot houses of the large packets running to St. Louis. To accommodate the large tows, they consider that a channel span of 650 feet is the least admissible, and that this width may have to be increased in special cases, at the dis-

cretion of the Board of Engineer Officers elsewhere provided for. To understand the necessity of this great width of span, the size of tows and the manner of handling them must be explained. The diagram annexed to this report shows a tow made up of seven barges and a towboat. Each barge is 235 feet long by 41 feet beam, and carries, when the stage of water permits, 50,000 bushels of wheat, or 1,500 tons of that or other freight. The whole tow, including the steamer, which is firmly fastened to the barges in the position indicated, measures 660 feet in length and 205 feet in breadth. The barges, with their upper works or cargo boxes, expose about 15 feet of height above the surface of the water. In descending a stream, if the channel is straight, the towboat pushes the tow along, but if the channel is crooked, especially if the current is strong, the limit of capacity of steering by means of the rudders of the steamer is soon reached. When this is the case the engines are reversed and the stern of the boat thrown away from the concave shore. The tow then lies more or less obliquely to the current and is carried on by it, the towboat meanwhile, by backing when necessary, preserving a safe distance between the tow and the bank. The degree of obliquity of the tow to the current depends upon the velocity of the latter and the degree of curvature of the channel; in extreme cases it may be absolutely at right angles to the current. This operation is technically known as flanking, and with the tortuous channels and sweeping bends of the lower river is of almost constant occurrence. Owing to the extent of surface exposed to its action, the effect of wind on one of these unwieldy tows is also very great, and for all these reasons it is necessary, to insure safety, that the channel spans of bridges through which they are expected to pass, should considerably exceed the width of the tows, and in extreme cases even their length, to provide against the contingency of their arriving at the bridge broadside on. (Annual Report, Chief of Engineers, 1888, p. 2380.)

Attention is invited to the fact that at least one channel span of not less than 650 feet clear channelway is required, and that the provisions of section 4, relating to increasing the number of channel spans at locations where the channel is shifting and variable, are particularly applicable to all of the Mississippi River below St. Louis.

A provision is inserted that all bridges in St. Louis Harbor below the Eads Bridge shall have but one pier within the 1,500 feet permanent waterway. All such bridges must therefore have two spans of 750 feet each or one span greater than 750 feet. A further provision is also inserted that within the city limits no bridge shall be built nearer than 1 mile to an existing bridge unless the proposed bridge shall cross the 1,500 feet waterway by a single span. The conditions at St. Louis, as in all harbors, are peculiar, and require special treatment. The river is partially contracted, and is intended to be contracted throughout to a width of only 1,500 feet—much less than the normal. Through this narrow section must pass practically all of the high-water flow of the river, with a consequent increase in the current velocities. The local transfer and ferry traffic is large, and the difficulties and dangers now attending it will be materially increased by every additional bridge with a pier in the waterway. The Board feels that it has placed only such restrictions upon these additional obstructions as the needs of navigation urgently require. The most recent bill (act approved March 3, 1897) authorizing the construction of a bridge at St. Louis required that, if built at any point below the Eads Bridge, it should have but a single span and a height of 75 feet. On account of the strong currents and large local traffic, the Board is of the opinion that single spans should be required of all bridges less than 1 mile apart, and that one pier per mile is all that should be permitted in the lower harbor.

Section 19.—Below the mouth of the Ohio the volume of water is more than doubled, and corresponding care is necessary in avoiding undue encroachment on the waterway. The navigation interests are increased by the Ohio River fleets, and demand greater facilities. As

on the Ohio, the coal tows are the controlling feature in regulating the minimum admissible length of span. These tows have now attained a size of 40 and more boats, carrying more than 1,000,000 bushels of coal, and on account of the relative economy of large tows it is probable that their use will be continued where and when circumstances permit.

* * * They are handled in essentially the same manner as already described when speaking of the preceding section, but owing to their great size and weight, and the tortuous course of the stream, the operation of flanking is in almost constant requisition. Owing to the increase in the volume of water as well as in the demands of navigation, the Board consider it necessary that the length of all spans should be made greater than above Cairo. The clear headroom should also be increased for several reasons. First, on the lower portion of the river, at least, a larger class of boats is used; second, the duration of high water is much longer, the river, at times of flood, remaining for days and even weeks in close proximity to extreme high-water mark, hence detention due to insufficient height would be more frequent and of longer duration; third, the present high-water marks are no safe criterion for the future, since the general leveeing of the river front, now rapidly progressing, is certain to make many changes, and will probably result in at least a temporary raising of flood levels. * * * (Annual Report, Chief of Engineers, 1888, p. 2381.)

This matter was carefully considered by the Mississippi River Commission in the case of a proposed bridge at Memphis, and their conclusion and recommendation, based on actual observations on coal tows passing the town, were that a channel span of at least 1,000 feet clear waterway was required at that place.

The present Board is of the opinion that over the Mississippi River, south of Cairo, a minimum width of channel span of 1,000 feet should be required, as on the Ohio River between Louisville and Cairo, and that no span over the waterway should be less than 600 feet.

Section 20 agrees in all material respects with section 19 of the bill prepared by the 1888 Board, and the remarks thereon of the latter Board are here inserted:

This is section 20 of the original bill, which was founded on the first Ohio River bridge act, approved December 17, 1872. The section has been rewritten and is now based on the new Ohio River bridge act, approved February 14, 1883. The additions to this act, not including minor changes, which do not affect the requirements, are that the Secretary of War is given authority, on the recommendation of the Board of Engineers, to refuse permission to construct a bridge in any special locality if it is not a public necessity, or, if erected under the special conditions and circumstances pertaining to the locality, would be an insuperable obstruction to navigation. The new section is also a little more full in its requirements as to accessory works, which experience has shown to be especially necessary in the case of bridges on the upper Mississippi and Illinois rivers where the spans are comparatively small. The section authorizes, on the recommendation of the Board of Engineers, such changes in the general requirements of this act as may be rendered necessary by the physical characteristics of the locality, or that can be made without injury to the interests of navigation. This proviso seems necessary, as otherwise the general requirements, which in most cases would be sufficient, might prohibit a bridge in some special locality where variation might be allowed without injury to anyone, while in other cases such variations might be absolutely indispensable to the safety of navigation.

The section also requires the proper maintenance of both bridges and their accessory works. Experience has shown that these may be built in accordance with the requirements of law, but not so maintained and kept in repair as to prevent the unnecessary obstruction naturally resulting from letting various parts of the structures go to ruin. (Annual Report Chief of Engineers, 1888, pp. 2381–2382.)

Section (20) of the bill of the 1888 Board, relating to the enforcement of certain provisions of the act, is omitted as being covered by existing general law.

Section 21 is slightly modified from the provisions of the 1888 act, and certain things required to be done by the latter act are placed under the discretion of the Secretary of War.

Section 22 is the same as the old section, with some minor changes in the wording.

Section 23 is the same as the old section, but the settlement of disputes arising thereunder is to be by the United States circuit court instead of by the Secretary of War.

Section 24 is essentially the same as the old section, but the last clause of the latter is stricken out as the prohibition therein contained is provided elsewhere in the act.

Section 25 is essentially the same as the old section, but a clause is added to emphasize the understanding that "the fact that such bridges were constructed under the supervision of the United States shall not be held to be a bar to the enforcement of this requirement" that changes and alterations shall be made at the expense of the owners of the bridge.

Section 26.—The greater part of this section is taken from the 1888 bill with some minor changes. A provision is added that channel in customary use shall not be temporarily obstructed or closed until after due notice to navigation has been given. And it is also required that all works used in bridge construction and repair shall be removed within a reasonable time after the completion or the repair of the bridge.

Section 27 is the same as in the 1888 act.

Section 28 of the old act is so modified that all former acts or parts of acts, of dates prior to January 1, 1899, granting authority for the construction of bridges over the rivers named in this act, are repealed in every case where actual construction is not commenced previous to the passage of this act. It is the object of this section to continue in force special acts passed since January 1, 1899, since these acts will of themselves expire by time limitation, and a revocation of such recent legislation might cause delay and consequent hardship in special cases; but to repeal all such legislation of older date, much of it being still alive by reason of having no time limit set as to the commencement or completion of construction. This action is considered absolutely necessary, as there are now in existence many acts, some of them very old, that provide entirely inadequate protection for the navigation interests. This general act has been more carefully drawn than any previous special acts, and as its main object is to guarantee in the future the construction of properly designed bridges it would be unjust to parties building under its provisions, and to the navigation interests as well, to allow an improper class of bridges to be built under the provisions of some old charter not sufficiently guarded in its requirements. It is believed that in all the acts alluded to, the right to amend or repeal was expressly reserved by Congress.

Section 29 is the same as in the 1888 bill, with the addition of a clause to emphasize the retained right of the United States to repeal this act or to require the removal of bridges erected under its authority, without any liability for damages on account of its exercise.

Section 30 is the usual clause repealing all laws or parts of laws in conflict with this act.

Copies of the following papers are transmitted herewith:

1. Draft of bill prepared by the Board.
2. Order constituting the Board.[1]
3. Minutes of the proceedings of the Board.[1]

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[1] Not printed.

4. Correspondence transmitted to the Board by the Chief of Engineers, U. S. A.[1]
5. House bill 1065, Fifty-sixth Congress, first session.[1]
6. Bill prepared by the Board of Engineer Officers constituted by Special Order No. 1, Headquarters, Corps of Engineers, 1888.[1]
7. Letter from the Pittsburg Coal Exchange.[1]
8. Statement of relative costs of tows of various sizes.[1]
9. Plan of tow of steamer *Jos. B. Williams.*[1]
10. Paper on "Bridging rivers."[1]

Very respectfully, your obedient servants,

M. B. ADAMS,
Lieut. Col., Corps of Engineers.
CHAS. F. POWELL,
Major, Corps of Engineers.
J. H. WILLARD,
Major, Corps of Engineers.
W. H. BIXBY,
Major, Corps of Engineers.
DAN C. KINGMAN,
Major, Corps of Engineers.
H. F. HODGES,
Captain, Corps of Engineers.
EDW. BURR,
Captain, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

DRAFT OF BILL.

A BILL To authorize the construction of bridges across the Ohio, Monongahela, Allegheny, Great Kanawha, Cumberland, Tennessee, and Illinois rivers, and the Mississippi River between the mouth of the Minnesota River and the city of Natchez, Mississippi, and to regulate the location, dimensions, and character of the same.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That any persons, companies, or corporations, having lawful authority, may hereafter, when public necessity so demands, erect bridges across the Ohio, Monongahela, Allegheny, Great Kanawha, Cumberland, Tennessee, and Illinois rivers, and the Mississippi River between the mouth of the Minnesota River and the city of Natchez, Mississippi, at points where said construction will not unreasonably obstruct navigation, upon compliance with the provisions and requirements of this act; and hereafter no bridge shall be built over said rivers within said limits except under the said provisions and requirements.

SEC. 2. That the sections of this act numbered one, two, three, four, five, six, seven, eight, twenty, twenty-one, twenty-two, twenty-three, twenty-four, twenty-five, twenty-six, twenty-seven, twenty-eight, twenty-nine, and thirty shall be general, and shall apply to all bridges authorized by this act; and that the sections numbered nine, ten, eleven, twelve, thirteen, fourteen, fifteen, sixteen, seventeen, eighteen, and nineteen shall apply specifically to bridges at such points on the Ohio, Monongahela, Allegheny, Great Kanawha, Cumberland, Tennessee, and Illinois rivers, and the Mississippi River between the mouth of the Minnesota River and the city of Natchez, Mississippi, as are covered by the sections enumerated.

SEC. 3. That wherever the phrases "high water," "pool level," or "low water" are used in this act they shall be held to mean the local high water, pool surface, and low water at the bridge site as determined by the Engineer Bureau of the War Department; and wherever the phrase "clear headroom" is used it shall be held to mean

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[1] Not printed.

the clear height measured from the water surface to the lowest part of the superstructure or anything thereunto attached in any span; and wherever the phrase "clear channel way" is used it shall be held to mean the clear width of openings at low water, but measured in a direction at right angles to the current of the river at the stage of water which is most important to navigation; and wherever the phrase "length of span" is used it shall be held to mean the distance between centers of adjacent piers measured on the center line of the bridge; and wherever the phrase "high bridge" is used it shall be held to mean a bridge with a fixed superstructure designed to allow the passage of boats beneath it; and the phrase "low bridge" shall be held to mean a bridge with one or more spans designed to be opened for the passage of boats through them at all stages of water.

Sec. 4. That in all high bridges authorized by this act, except as hereinafter provided, every span over the waterway between the shore lines of the river at a bankfull stage shall give a clear headroom not less than that prescribed for those over the channel ways; also that in such high bridges one or more wide or channel spans, of lengths to be hereinafter prescribed, shall be placed over the main channel or channels of the river, and in case the channel is variable the number of channel spans shall be increased so that there may be a channel span available for any position of the channel.

Sec. 5. That all low bridges authorized by this act shall be so located that a good channel can be kept and maintained for the passage of boats at all navigable stages of water, and that the said channel shall be made easily accessible by boats at all such stages; and that the draw opening or openings shall be located over said channel in such manner that one or all of the openings can be conveniently and safely reached by boats at all navigable stages of water; and that one draw opening at least shall be over the best and most convenient channel of the river at any stage of water; and said draw opening, where practicable, shall be visible from all parts of the channel for a distance of not less than one mile above said opening.

Sec. 6. That all piers shall be built parallel to the current of the river at that stage of water which is most important for navigation; and the bridge itself shall be built as nearly as may be at right angles thereto; and that riprapping or other protection for imperfect foundations which will lessen the required waterway shall not be permitted; also that piers which would produce cross currents or bars dangerous to navigation shall not be constructed; and if after construction any piers or accessory works are found to produce the above-mentioned effects, or if any riprapping or other protection prohibited by this section is found to exist, the nuisance shall be abated or corrected in accordance with existing law.

Sec. 7. That in the case of all bridges built under the provisions of this act the approaches to the bridge shall be so designed and constructed as not to interfere with the free discharge of the river in seasons of flood, and any encroachment on the high-water cross section by piers, solid embankments, or otherwise, which might result in unduly accelerating the high-water current at the site of the bridge shall not be allowed. If, by reason of the location of a bridge in or near a city harbor, or from any other cause, the draw opening, channel, or raft span next the shore shall appear or become difficult of access at any season because of the proximity of river craft which are or may be moored at the bank, or from any other cause, then the person, company, or corporation owning, controlling, or operating said bridge shall either increase the width of the opening or span sufficiently, or shall, by purchase or otherwise, extinguish the right to obstruct the entrance to said draw opening or span for a distance of from five hundred to one thousand feet both above and below the bridge, as may appear necessary.

Sec. 8. That any person, company, or corporation constructing any bridge under authority of this act shall build and maintain at all times, as accessory works to such bridge, such booms, piers, dikes, guard fences, and such other devices as may be necessary to insure at all times a permanent channel for a sufficient distance above and below the bridge site, and for the guiding of rafts, steamboats, and other water craft safely under or through said bridge; and if at any time after the construction of the bridge and its accessory works the approaches to draw openings, channel spans, or raft passages in bridges over the navigable waters referred to in this act are found to be dangerous or difficult of access by any important class of river traffic, the nuisance shall be abated or corrected in accordance with existing law; and wherever practicable and in the interests of navigation all bridges located in the vicinity of important landings shall be placed above rather than below said landings; and that in all bridges with channel or raft spans or draw openings of less than three hundred feet clear channel way authorized by this act there may be required, as a part of the necessary accessory works provided for in this act, one or more protection piers of masonry, crib work, or piling, or one or more sheer booms, as may be directed by the Secretary of War, extending from the end or ends of such spans or openings

upstream for a distance of one thousand feet or less from the center line of the bridge; and the said protection pier or piers shall be properly arranged with ringbolts, cavils, snubbing posts, or similar accessories, and fender planking, so as to enable boats or rafts to tie up alongside and drop down through the draw openings, channels, or raft spans at such times as it may be dangerous to attempt the passage of the same when under headway; and in addition to the said protection pier or piers the Secretary of War may also require as a part of said accessory works, when a draw opening or raft span is near shore, that the end of the opening or span be connected with the shore by a substantial guard fence extending upstream in such direction and to such distance as will render access to the said draw opening or raft span easy and safe at all times.

SEC. 9. That all bridges authorized by this act over the main channels of the Ohio River shall be high bridges with unbroken and continuous spans, having at least one channel span placed over that part of the river usually run by descending coal fleets, said channel span to have a clear channel way of not less than eight hundred feet if located above the Louisville and Portland Canal and not less than one thousand feet if located below the Louisville and Portland Canal, and to have a clear headroom of not less than forty feet above high water and not less than ninety feet above low water if located above the mouth of the Big Sandy River, and not less than forty feet above high water and not less than one hundred and four feet above low water if located below the mouth of the Big Sandy River, low water to be taken as that of eighteen hundred and eighty-one and high water as that of eighteen hundred and thirty-two; and that all other spans over the waterway of this river or of its side canals or secondary channels of useful navigability behind islands shall have the same or a reduced channel way and headroom and draw openings, if necessary, according to the approved recommendation of the Board of Engineers provided for in section twenty of this act.

SEC. 10. That all bridges authorized by this act over the Monongahela River shall have not less than five hundred feet clear channel way at their wide or channel spans and a clear headroom at the same of not less than fifty-four feet above pool surface: *Provided*, That the clear headroom at other spans may be reduced in accordance with section twenty of this act.

SEC. 11. That all bridges authorized by this act over the Allegheny River, Pennsylvania, shall have not less than four hundred feet clear channel way at their wide or channel spans at locations downstream from Hickory Creek and not less than two hundred and fifty feet clear channel way at locations upstream from Hickory Creek; and the clear headroom of said channel spans at locations downstream from Sixth street, Pittsburg, shall be not less than seventy-three feet above pool surface and at locations upstream therefrom to Oil Creek at Oil City shall be not less than fifty feet above established or proposed pool surface, or above low water where the pool surfaces are not established or proposed, and at locations upstream from Oil Creek shall be not less than forty feet above low water: *Provided*, That the clear headroom of spans over island channels may be reduced in accordance with section twenty of this act.

SEC. 12. That all bridges authorized by this act over the Great Kanawha River in West Virginia shall be high bridges, with the axes at right angles to the current at high towing stages, and with unbroken and continuous spans, all of which shall be through spans. Every such bridge shall have at least one channel span, the center of which shall be in the middle of the channel usually run by decending coal fleets at high towing stages, said channel span to have a clear channel way of not less than four hundred feet. Said channel span shall have a clear headroom of not less than twenty-nine feet above local highest water as determined by the Engineer Bureau of the War Department, and a clear headroom above low water which shall be not less than ninety feet for bridges built at or near Point Pleasant, and not less than seventy-five feet for bridges built at or near Charleston.

SEC. 13. That all high bridges authorized by this act over the Cumberland River shall have at least one channel span with a clear channel way of not less than two hundred and fifty feet and a clear headroom of not less than one hundred feet above low water, and all low bridges authorized by this act over the Cumberland River shall have at least one drawspan with a clear channel way of not less than one hundred and seventy-five feet: *Provided*, That every part of the superstructure of low bridges shall afford a clear headroom of not less than six feet above high water.

SEC. 14. That all high bridges authorized by this act over the Tennessee River above Market street of the city of Chattanooga, Tennessee, shall have one or more channel spans, each with a clear channel way of not less than three hundred feet and a clear headroom of not less than one hundred feet above low water, and no span between the banks shall be less than two hundred feet; that all low bridges authorized by this act over the Tennessee River above the said Market street shall have

two or more draw openings, each with a clear channel way of not less than one hundred and fifty feet; and in addition to these draw openings all low bridges shall have one or more fixed channel spans, each with a clear channel way of not less than three hundred feet, and every part of said low bridges shall have a clear headroom of not less than six feet above high water; that all high bridges authorized by this act over the Tennessee River below said Market street shall have one or more channel spans, each with a clear channel way of not less than five hundred feet and a clear headroom of not less than one hundred feet above low water, and no span between the banks shall be less than two hundred and fifty feet; that all low bridges authorized by this act over the Tennessee River below said Market street shall have two or more draw openings, each with a clear channel way of not less than two hundred feet; and in addition thereto all low bridges shall have one or more fixed channel spans, each with a clear channel way of not less than three hundred feet, and every part of said low bridges shall have a clear headroom of not less than six feet above high water.

SEC. 15. That all high bridges authorized by this act over the Mississippi River below the mouth of the Minnesota River and above the mouth of the Missouri River shall have one or more channel spans, each with a clear channel way of not less than three hundred and fifty feet and a clear headroom of not less than fifty-five feet above high water, and the clear headroom of other than channel spans may be less than fifty-five feet: *Provided*, That no part of such spans shall have a less headroom than ten feet above high water: *And provided further*, That the interests of navigation be not injured by such reduction in height. That all low bridges within the above-mentioned limits shall have two or more draw openings, each with a clear channel way of not less than two hundred feet, and in addition to said draw openings all said low bridges shall have one or more fixed channel spans, each with a clear channel way of not less than three hundred and fifty feet, and every part of said low bridges shall have a clear headroom of not less than ten feet above high water: *Provided also*, That for any two adjacent draw openings of two hundred feet each one draw opening of three hundred feet clear chanel way may be substituted if the interests of navigation be not injured thereby: *Provided further*, That all bridges authorized by this act over the Illinois and Des Plaines rivers shall be low bridges having two or more draw openings, each with a clear channel way of not less than one hundred and sixty feet, and such low bridges shall comply with all of the requirements of this act relating to low bridges over the Mississippi River above the mouth of the Missouri River, excepting only as to the clear channel way of the draw openings: *Provided further*, That on the Mississippi River above the mouth of the Missouri River and on the Illinois and Des Plaines rivers bridges may be constructed as pile and pontoon bridges, similar to the pontoon railway bridge at Prairie du Chien, Wisconsin, legalized by the act of Congress approved June sixth, eighteen hundred and seventy-four, and such bridges shall be provided with a pontoon draw, with a clear channel way of not less than four hundred feet for each navigable channel of the river, and with such other openings for the passage of rafts and logs as in the opinion of the Secretary of War may be necessary: *And provided further*, That pile and pontoon bridges shall be subject to all the restrictions and requirements of this act so far as they are applicable to such pile and pontoon bridges.

SEC. 16. That all bridges authorized by this act over the Mississippi River between the mouth of the Missouri River and the northern limits of the city of Saint Louis, Missouri, shall be high bridges, with unbroken and continuous spans, having at least one channel span with a clear channel way of not less than five hundred feet; and all other spans over the waterway shall have a clear channel way of not less than four hundred feet, and all said spans shall have a clear headroom of not less than fifty-five feet above high water.

SEC. 17. That all bridges authorized by this act over the Mississippi River between the Eads Bridge at Saint Louis and the northern limit of said city shall be high bridges with unbroken and continuous spans, and shall have over that portion of the river bed embraced between the wharf line of the city of Saint Louis as now established, or as may hereafter be established within the limits specified, and a line parallel thereto and fifteen hundred feet distant therefrom, spans each with a clear channel way of not less than five hundred feet and with a clear headroom of not less than fifty-five feet above high water. The spans over the remaining portion, if any, of the river bed shall each have a clear channel way of not less than three hundred feet, and may have such reduced headroom as, in the opinion of the Board of Engineers provided for in section twenty of this act, will not be prejudicial to the interests of navigation.

SEC. 18. That all bridges authorized by this act over the Mississippi River between the Eads Bridge at Saint Louis, Missouri, and the mouth of the Ohio River shall be high bridges with unbroken and continuous spans, having at least one channel span

with a clear channel way of not less than six hundred and fifty feet, and all other spans over the waterway shall each have a clear channel way of not less than five hundred feet, and all spans shall have a clear headroom of not less than sixty-five feet above high water: *Provided*, That all bridges authorized by this act over the Mississippi River between the Eads Bridge at Saint Louis and the southern limits of said city shall have but one pier in that portion of the river bed embraced between the wharf line of the city of Saint Louis, as now established or as may hereafter be established, within the limits specified, and a line parallel thereto and fifteen hundred feet distant therefrom: *And provided further*, That between the northern and southern limits of the city of Saint Louis no bridge shall be built nearer than one mile to any existing bridge unless the proposed bridge shall have a single span over that portion of the river bed between the wharf line of the city of Saint Louis as defined above, and a line parallel thereto and fifteen hundred feet distant therefrom.

SEC. 19. That all bridges authorized by this act over the Mississippi River between the mouth of the Ohio River and Natchez, Mississippi, shall be high bridges with unbroken and continuous spans having at least one channel span with a clear channel way of not less than one thousand feet; and all other spans over the waterway shall each have a clear channel way of not less than six hundred feet, and all spans shall have a clear headroom of not less than seventy-five feet above high water.

SEC. 20. That any authorized person, company, or corporation intending to construct a bridge under the provisions of this act shall give notice for one month of such intention, stating the kind of bridge and location, by continuous publication in newspapers having a wide circulation, as follows: In not less than two newspapers in each of the cities of Pittsburg, Cincinnati, Louisville, Saint Louis, Memphis, and New Orleans for bridges across the Ohio River; in two newspapers in the city of Pittsburg for bridges across the Monongahela River or the Allegheny River; in one newspaper in each of the cities of Charleston, Kanawha County, West Virginia, and Gallipolis, Ohio, and in two newspapers in each of the cities of Louisville, Pittsburg, and Cincinnati for bridges across the Great Kanawha River; in one newspaper in each of the cities of Knoxville, Chattanooga, Nashville, Evansville, Cairo, and Saint Louis for bridges across the Tennessee River or the Cumberland River; in one newspaper in each of the cities of Chicago and Peoria and in two newspapers in the city of Saint Louis for bridges across the Illinois River; in not less than one newspaper in each of the cities of Saint Paul, La Crosse, Dubuque, Rock Island, Keokuk, Saint Louis, and Chicago for bridges across the Mississippi River above the Eads Bridge at Saint Louis; and in not less than two newspapers in each of the cities of Pittsburg, Cincinnati, Louisville, Saint Louis, Memphis, and New Orleans for bridges across the Mississippi River below Saint Louis; and shall submit, in triplicate, to the Secretary of War, for his examination, upon a convenient scale, a design and drawings of the bridge, piers, approaches, and accessory works, and a map of the location, giving, for the space of at least two miles above and one mile below the proposed site, the topography of the banks of the river and the shore lines at high and low water; and this map shall be accompanied by another, drawn on the scale of one inch to two hundred feet, giving, for a space of one-half a mile above the proposed site and a quarter of a mile below, an accurate representation of the bottom of the river, by contour lines two feet apart, determined by accurate soundings, and also showing over the whole width of this part of the river the force and direction of the currents at low water, at high water, and at least one intermediate stage, by triangulated observations on suitable floats; and these maps shall also show the location of other bridges, locks and dams, coal tipples, cribs, and all other structures projecting into the river at bank-full stage, in the vicinity, and shall give such other information as the Secretary of War may require for a full and satisfactory understanding of the subject. Said maps and drawings shall be referred to a Board of Officers of the Corps of Engineers, United States Army, for examination and report, which Board shall personally examine the site of the proposed bridge and shall hold a public session at some convenient point to hear all objections thereto, of which public session due notice and invitation to be present shall be given to all interested parties by advertising, and such parties shall be allowed sufficient time for a full examination and consideration of the plans; and if said Board of Engineers reports that the bridge is not a public necessity or that the location selected is unsuitable for a bridge, the bridge shall not be built; or if said Board reports that plans presented are unfavorable to the interests of navigation at the site proposed, the Secretary of War shall be authorized, on recommendation of said Board, to refuse permission for the construction of a bridge at the proposed site until such changes in the design of the bridge or the location of its piers as may be deemed necessary shall have been made, and to require, in the same way, at the expense of the parties constructing such bridge, the construction of such dikes, booms, piers, or other auxiliary

structures as may be needed for confining the flow of water to a permanent channel for a distance of not less than one mile above the bridge site and for a proper distance below, and for guiding rafts, steamboats, and other water craft safely under said bridge or through the draw and raft spans; but in no case shall there be a reduction in the number, width, or headroom of draw, raft, channel, or other span, or in the arrangement and length of accessory works required by this act, unless such reduction is made necessary by the physical characteristics of the river in the locality where the bridge is proposed or is shown clearly to be not injurious to the interests of navigation; and the proposed bridge shall be a lawful structure only when built in accordance with the plans as recommended by the said Board of Engineers and approved by the Chief of Engineers and the Secretary of War, and while so managed and kept in repair as to offer at all times reasonable and proper means for the passage of rafts, steamboats, and other water craft through or under said bridge, and while all the requirements of this act are observed.

SEC. 21. That all persons, companies, or corporations owning, controlling, or operating bridges authorized by this act shall maintain at their expense such lights and other signals on the bridges as may be required by the Light-House Board, as well as any other lights and signals as may be necessary for the security of navigation in the vicinity of the bridge; and shall also be required to maintain such indications of the stage of water and the headroom under the bridge as the Secretary of War may direct.

SEC. 22. That any bridge constructed, maintained, and operated under this act and according to its limitations shall be a lawful structure and shall be recognized and known as a post route, upon which also no higher charge shall be made for the transportation over the same of the mails, the troops, and the munitions of war of the United States than the rate per mile paid for the transportation of said mails, troops, and munitions over the railroads and public highways leading to said bridge; and the United States shall have the right of way for postal telegraph and telephone purposes over any such bridge; and in case of any litigation arising from any alleged obstruction to the navigation of any of said rivers created by the construction of any bridge under this act the cause or question arising may be tried before the circuit court of the United States in and for any district in which any portion of said obstruction or bridge may be.

SEC. 23. That all railroad companies desiring the use of any railroad bridge constructed under this act shall have and be entitled to equal rights and privileges relative to the passage of railway trains or cars over the same, and over the approaches thereto, upon payment of a reasonable compensation for such use; and in case the parties interested shall fail to agree upon the sum or sums to be paid and upon the rules and conditions to which each shall conform in using said bridge all matters at issue between them shall, upon the application of either party, be determined by the circuit court of the United States in and for any district in which any portion of said bridge may be.

SEC. 24. That the persons, companies, or corporations constructing bridges under the provisions of this act shall have the right to construct safe and suitable passageways thereon for foot passengers and vehicles of every description, and to charge a reasonable toll for the use thereof; but the rates of toll shall be submitted to the Secretary of War, and shall be subject to his approval and to any changes he may think proper from time to time.

SEC. 25. That such alterations and changes as may be required by the Secretary of War in accordance with existing law in bridges constructed under the provisions of this act, so as to preserve free and convenient navigation, shall be made under the direction of the Secretary of War at the expense of the persons, companies, or corporations owning, controlling, or operating said bridges, and the fact that such bridges were constructed under the supervision of the United States shall not be held to be a bar to the enforcement of this requirement, and nothing contained in this act shall be construed as exempting any bridge built under authority thereof from the operation of the existing laws for the protection of the navigation of rivers.

SEC. 26. That all bridges constructed under the authority of this act shall be built under the general supervision of the Secretary of War, and no changes or alterations in plans shall be made during construction of said bridges or after their completion, unless said changes or alterations conform to the provisions of this act and are recommended by the Chief of Engineers and approved by the Secretary of War. That during the original construction of any bridge built under the provisions of this act, or in carrying out any authorized changes or repairs of said bridge, a navigable channel sufficient to accommodate the commerce of the river shall be preserved at all times at the site of said bridge, and the waterway of the river shall not be obstructed to a greater extent than is absolutely necessary, and such lights and

buoys shall be kept on all cofferdams, piles, and other structures as may be necessary for the security of navigation; and that any temporary obstruction or closing of any channel in customary use shall not be commenced until after due notice to navigation; and all cofferdams, piles, and other structures used in the construction or repair of said bridge shall be removed within a reasonable time after the completion or repair of said bridge.

Sec. 27. That any permission granted by the Secretary of War under the provisions of this act for the construction of a bridge across any river hereinbefore mentioned shall be null and void if said construction be not actually commenced within one year and completed within three years from the date of said permission.

Sec. 28. That all former acts or parts of acts of dates prior to January first, eighteen hundred and ninety-nine, granting authority for the erection of any bridge or causeway across any portion of the rivers set forth in section one of this act, be, and the same are hereby, repealed in each and every case where actual construction of said bridge or causeway be not commenced on or before the date of this act.

Sec. 29. That the right to alter, amend, or repeal this act is hereby expressly reserved; and the right to require, at the expense of the owners, the entire removal of any bridge constructed under the provisions of this act whenever Congress shall decide that the public interests so require is also expressly reserved; and the United States shall not be liable for damages arising from the exercise of the rights thus expressly reserved.

Sec. 30. That all laws and parts of laws that may be in conflict with this act are hereby repealed.

APPENDIX F F F.

BRIDGES AT WASHINGTON, DISTRICT OF COLUMBIA.

REPORT OF LIEUT. COL. CHAS. J. ALLEN, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1900, WITH OTHER DOCUMENTS RELATING TO THE WORKS.

UNITED STATES ENGINEER OFFICE,
Washington, D. C., July 20, 1900.

GENERAL: I have the honor to forward herewith my annual report for year ended June 30, 1900, for Memorial Bridge and repairs to the Aqueduct Bridge.

Very respectfully, your obedient servant,

CHAS. J. ALLEN,
Lieut. Col., Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

F F F 1.

REPAIR OF THE AQUEDUCT BRIDGE ACROSS THE POTOMAC RIVER AT WASHINGTON, DISTRICT OF COLUMBIA.

For an account of operations preceding the appropriation of June 8, 1896, for the reconstruction of Pier No. 4 of this bridge, reference is made to Appendix AAA to the Annual Report of the Chief of Engi-

neers for 1898, pages 3883–3889, and for statement of operations preceding the making of the contract of May 12, 1899, with the Central Contracting Company, of New York, for reconstruction of the pier, this contract to be completed July 31, 1900, reference is made to the Annual Report, 1899, pages 3777–3778.

Effort was made by the contractors in the summer of 1899 to obtain permission to use a different dimension stone from that specified in the contract, and which, the larger sizes especially, they claimed it was impracticable to obtain, but the permission sought was not granted. Their plant began to arrive at the work July 22, and about August 25 the contractors began to make active preparations toward opening a quarry near Chain Bridge. The quarrying and dressing of stone for ashlar masonry for the faces of the pier was begun September 14, 1899, and continued until April, 1900, when a sufficient quantity to practically complete the work had been obtained. It has been estimated that a total of 315 cubic yards of dimension stone was quarried and dressed by the contractors at their quarry near Chain Bridge and that about three-fourths of the stone obtained during the first three months' operations was for the deepest courses (18-inch to 24-inch). The rest of the stone for the ashlar masonry was, as reported, purchased by the contractors from the Houston Construction Company.

The stone for interior headers is granite obtained in Maine.

The stone has been transported down the Chesapeake and Ohio Canal and stored in the contractors' yard near the north abutment of the Aqueduct Bridge.

The contractors placed some pumping plant upon the cofferdam late in the summer of 1899, but removed it to the shore for safe-keeping early in the following winter. On April 4, 1900, active work began at the cofferdam. The pumps and machinery for handling materials have been installed, the false works and cofferdam repaired where necessary, and the cofferdam has been tightened. The pumping plant was further increased toward the end of June. It is now hoped that the work will progress rapidly and be completed early in the next fiscal year.

Money statement.

July 1, 1899, balance unexpended		$55,748.02
June 30, 1900, amount expended during fiscal year		2,095.65
July 1, 1900, balance unexpended		53,652.37
July 1, 1900, outstanding liabilities	$70.00	
July 1, 1900, amount covered by uncompleted contracts	37,747.00	
		37,817.00
July 1, 1900, balance available		15,835.37

F F F 2.

MEMORIAL BRIDGE ACROSS POTOMAC RIVER AT WASHINGTON, DISTRICT OF COLUMBIA.

Congress by act approved March 3, 1899 (Public—No. 188), made the following appropriation:

Memorial bridge across Potomac River: To enable the Chief of Engineers of the Army to continue the examination of the subject and to make or secure designs, calculations, and estimates for a memorial bridge from the most convenient point of the Naval Observatory grounds or adjacent thereto across the Potomac River to the most convenient point of the Arlington estate property, the sum of five thousand dollars.

It having been decided to invite competitive designs from a limited number of prominent and experienced bridge engineers and designers, each of whom was to associate with himself in the work of the design an architect of ability and reputation, Messrs. Leffert L. Buck, William H. Burr, William R. Hutton, and George S. Morison were invited by the Department to present such designs, to be delivered by January 16, 1900. The time was subsequently extended to January 31. By that date the designs with detail drawings, stress sheets, etc., had all been received by this office.

There were nine designs in all submitted, illustrated by 90 drawings, including perspectives, plans, elevations, sections, profiles, and details. But a few of these were reproduced in the Board of Officers of the Corps of Engineers and Architects appointed to pass upon the plans, time and funds not admitting of the reproduction of all of them.

Reference is here made to that report which is published as Document No. 578, House of Representatives, Fifty-sixth Congress, first session. It is also herewith.

The specifications and estimates accompanying the design which was selected as the most suitable (Design No. 2, by Mr. Burr) are full, explicit, and clear. The estimate is as close as can be expected of an advance estimate for a large work of that kind. The plans, sections, profiles, and details (twelve in number) are in good shape for use. In case of an appropriation for this much-needed bridge, there will be nothing, so far as known, to prevent a prompt commencement of the work, including the preparation of materials, special detail drawings, such borings at the precise sites for piers and abutments as a prudent constructor would make, notwithstanding that a full survey, including borings, had previously been made, etc.

Money statement.

July 1, 1899, balance unexpended	$5,000.00
June 30, 1900, amount expended during fiscal year	4,772.76
July 1, 1900, balance unexpended	227.24

MEMORIAL BRIDGE ACROSS THE POTOMAC RIVER, AT WASHINGTON, D. C.

[Printed in House Doc. No. 578, Fifty-sixth Congress, first session.]

OFFICE OF THE CHIEF OF ENGINEERS,
UNITED STATES ARMY,
Washington, April 4, 1900.

SIR: I have the honor to forward herewith the report, in duplicate, dated the 28th ultimo, by the Board of Officers of the Corps of Engineers and of Architects, appointed by order of the Secretary of War to consider and report upon the relative merits of the designs submitted for a memorial bridge to be constructed across the Potomac River at Washington.

There were submitted for the consideration of the Board two designs each by Messrs. L. L. Buck, William R. Hutton, and George S. Morison, and three designs by Mr. William H. Burr. After careful study the Board places the comparative merits of the designs as follows:

No. 1. Design No. 2 of Mr. William H. Burr.
No. 2. Design No. 2 of Mr. William R. Hutton.
No. 3. Design No. 1 of Mr. L. L. Buck.
No. 4. Design No. 1 of Mr. George S. Morison.

The Board expresses the opinion that the general design of Mr. Burr's, designated as the first in the order of merit, meets the conditions of the problem and should be adopted, subject to certain recommendations and modifications set forth in the report, as to width, slope of roadway, curve of under side of draw, towers, provision for tram cars, elevation of initial point, etc., and such other minor modifications as experience may suggest upon the undertaking of the work or during its progress.

The estimated cost of Mr. Burr's structure, as designed originally, is $3,680,672; and the Board estimates that the modifications recommended will add about 32 per cent, bringing the total cost up to $4,860,000.

I concur in the views of the Board and recommend that they be approved by the Secretary of War, and that one copy of the report and accompanying papers be transmitted to the President of the Senate and the other copy to the Speaker of the House of Representatives.

The sundry civil act of March 3, 1899, appropriates $5,000 for securing the designs and estimates for this bridge.

Very respectfully, your obedient servant,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Hon. ELIHU ROOT,
Secretary of War.

REPORT OF BOARD OF ENGINEERS AND OF ARCHITECTS UPON CERTAIN DESIGNS FOR A MEMORIAL BRIDGE ACROSS POTOMAC RIVER FROM WASHINGTON, D. C., TO ARLINGTON, VA.

UNITED STATES ENGINEER OFFICE,
Washington, D. C., March 28, 1900.

SIR: The Board of Officers of the Corp of Engineers and of Architects appointed by order of the Secretary of War to consider and report upon designs presented for a memorial bridge to cross Potomac

River from Washington to Arlington, has the honor to submit the following report:

The appointment of the Board was promulgated in an order as follows:

SPECIAL ORDERS, No. 30. } [Extract.]

HEADQUARTERS OF THE ARMY,
ADJUTANT-GENERAL'S OFFICE,
Washington, February 5, 1900.

* * * * * * *

12. The following order has been received from the War Department:

"WAR DEPARTMENT,
"*Washington, February 5, 1900.*

"A Board of Officers of the Corps of Engineers and of Architects, to consist of—

"Lieut. Col. Charles J. Allen, Corps of Engineers; Maj. Thomas W. Symons, Corps of Engineers; Capt. David DuB. Gaillard, Corps of Engineers; Mr. Stanford White, architect; and Mr. James G. Hill, architect, will assemble in Washington, District of Columbia, upon the call of the chairman of the Board, to consider and report upon the relative merits of the plans submitted for a bridge to be constructed over the Potomac River at Washington, District of Columbia, as a memorial to American patriotism.

"Lieut. Col. Charles J. Allen is designated as chairman of the Board.

"The Board will give careful consideration to the plans presented, will determine their order of merit, and will report which plan, if any, in the judgment of the Board, should be adopted for the bridge to be constructed.

"Upon the completion of the duty assigned them the engineer members of the Board will return to their proper stations.

"The journeys required under this order are necessary for the public service, and the expenses of the Board will be paid from the appropriation for 'Estimate for memorial bridge across Potomac River.'

"ELIHU ROOT, *Secretary of War.*"

* * * * * * *

By command of Major-General Miles:

H. C. CORBIN, *Adjutant-General.*

The Board assembled on February 19, 1900, upon the call of the chairman, and, after examining and discussing the designs, adjourned until Tuesday, February 27, in order to allow time for certain computations and comparisons to be made.

The Board reassembled pursuant to the adjournment and continued the examination and discussion of the designs, and also examined the ground and approaches, in part, for the bridge crossing.

The following brief sketch of the steps taken since and including 1886 for the consideration of a bridge from Washington to Arlington will, it is believed, be of interest as well as of value to those who may not be acquainted with the history of the project. The sketch is partly from a report of a survey with reference to a memorial bridge across the Potomac River, from the Naval Observatory grounds,[1] Washington, to the Arlington estate, Virginia, made in 1897, under direction of the Chief of Engineers, by Lieut. Col. Charles J. Allen, Corps of Engineers. The report is printed as House Doc. No. 308, Fifty-fifth Congress, second session.

The survey of 1897 was made in accordance with the requirements of the following item in the sundry civil act of Congress, approved June 4, 1897:

Memorial bridge across Potomac River: To enable the Chief of Engineers of the Army to make the necessary surveys, soundings, and borings, and for securing designs and estimates for a memorial bridge from the most convenient point of the Naval Observatory grounds, or adjacent thereto, across the Potomac River to the most convenient point of the Arlington estate property, two thousand five hundred dollars.

[1] This refers to the old Naval Observatory grounds at the foot of New York avenue, Washington.

STEPS TAKEN TO SECURE A MEMORIAL BRIDGE.

The question of a suitable bridge across the Potomac, from Washington to Arlington, has been discussed more or less for the past twelve or fifteen years.

The United States Senate, on May 24, 1886, adopted the following resolution:

Resolved, That the Secretary of War be directed to examine and report upon the expediency of constructing a Government bridge, with a suitable draw and approaches, from a point at or near the foot of New York or New Hampshire avenue, on the public grounds, across the Potomac River and Analostan Island, to a point on the United States National Cemetery grounds at Arlington, so as to connect, in the best manner, the public grounds on the two sides of the Potomac, with estimates of the cost of the kind of bridge deemed by the Department most expedient, as well as the cost of alternative plans considered practicable, and which will not materially affect the navigation of the river.

The resolution was referred by the Chief of Engineers, General Newton, to Major (now Colonel) Hains, Corps of Engineers, for report.

Major Hains in his report proposed a bridge of four spans of about 300 feet length each, the second span from the Washington City side to be a pivot draw, the bridge to have carriageway 24 feet wide and two sidewalks each 8 feet wide; the main bridge structure to be about 1,200 feet long; the approach on the Washington side to be by a wide roadway on an embankment, with a grade of about 3 feet in 100; Analostan Island and the bed of Little River to be crossed partly by embankment and partly by open trestle supporting the roadway; the lower chord of the bridge to be placed at about 28 feet above the level of low tide; the piers and abutments to be built of solid masonry; the truss to be capable of bearing a moving load of about 75 pounds to the square foot of roadway. The cost of such a structure, finished in the best manner and with some degree of ornamentation, was estimated at $609,543. An alternative plan for three spans of steel was also given, the cost estimated at about $650,000. The bridges contemplated were to be through spans.

About the same time Captain (now Major) Symons, Corps of Engineers, submitted a plan for a bridge from Observatory Hill to Arlington, across the Potomac River, the bridge designed to be a link in a wide travel way from the Capitol to the National Cemetery and Government estate at Arlington, to pass at a sufficient height above the river to incommode commerce in the least possible manner, and to be monumental in its character. The main spans to be 306 feet in the clear, with a clear height above high tide of 90 feet under two of them. The span arches to be of steel. The approaches and a portion of the bridge across the lowlands designed to be in embankment 50 feet wide on top, well paved, and with sidewalks and a substantial railing.

This proposed bridge was memorial in its conception, and the cost estimated at from $1,000,000 to $1,500,000. It was to be "essentially a deck bridge with two partially through spans." Roadway 30 feet wide, with 8-foot sidewalks on each side. Piers to be handsome in design, of solid masonry.

The Chief of Engineers, General Newton, in submitting the reports and plans herein mentioned, and after expressing, in effect, the opinion that the plan for the latter bridge just mentioned did not appear to allow sufficient head room, wrote as follows:

It may be added that the limited time given for so important a subject rendered it impracticable to give more than a casual study of the question.

The proposed structure, whether viewed from a local or a national standpoint, would involve interests of such magnitude and importance as to demand, in my judgment, the careful consideration of a mixed board of engineers, whose duty it should be to give the plans to be adopted for the construction the fullest and most careful consideration; and it is recommended, should Congress provide for its construction, that such a board be authorized.

The full reports from which the foregoing brief statements are taken are printed in pages 892–897, Appendix I, Part II, of the Annual Report of the Chief of Engineers for 1886.

On the 20th of February, 1890, the Senate adopted the following resolution:

Resolved, That the Secretary of War be, and he is hereby, directed to examine and report to the Senate on the most suitable kind of bridge, with approaches, from a point at or near the foot of New York avenue across the Potomac River to a point on the United States National Cemetery grounds at Arlington, so as to connect in the best manner the public grounds on both sides of the Potomac River, with estimates of the kind of bridge deemed most expedient, and which will not interfere with the navigation of said river.

This was referred to Colonel Hains for report. From his report, dated April 17, 1890, and which, with drawings appertaining, is printed on pages 1045–1047, Appendix K, Part II, of the Annual Report of the Chief of Engineers for 1890, the following is taken:

With a view to meeting the objections to a drawbridge and at the same time to bring the cost of one without a draw within reasonable limits, I have designed a bridge on the suspension principle, the clear height above the water at midchannel to be 105 feet, the river span to be 1,100 feet, and two shore spans 652 feet each; the approaches at each end to be on masonry-arched viaducts and embankments of earth; the suspension cables to be of steel, passing over two granite towers, each 210 feet high. * * * The extreme width of bridge to be about 54 feet, with a roadway for vehicles 34 feet wide in the clear, and two sidewalks for pedestrians 8 feet wide.

The total length proposed for this bridge, including approaches, was 4,580 feet, and its estimated cost $3,591,000. Of this Colonel Hains stated that by reducing the width to 40 feet, making the roadway 24 feet wide instead of 34, a reduction of $500,000 could be made in the estimated cost, and that a still further reduction of about $400,000 could be made by building the approaches on iron trusses resting on masonry piers, but that these modifications would detract from the dignity of the structure and would not harmonize with the architectural features of other parts of the work.

This bridge was to cross the Potomac River at or near the Naval Observatory.

Senate bill 796, Fifty-second Congress, first session, introduced December 14, 1891, contained the following provisions:

* * * That the sum of fifty thousand dollars is hereby appropriated, out of any money in the Treasury not otherwise appropriated, for the purpose of laying off so much of the Arlington estate in Virginia, near Washington, District of Columbia, as may not be otherwise used, into a public park, to be known as "The Arlington Park," and making appropriate roads or avenues therein. The Secretary of War is hereby charged with the duty of expending the sum aforesaid for the purpose named.

SEC. 2. That the Secretary of War is authorized and directed to have constructed an iron bridge from the most convenient point of the Naval Observatory grounds across the Potomac River to the most convenient point of the Arlington estate property.

SEC. 3. That said bridge shall be constructed of iron, with a wagon way thirty feet wide and a passenger footway on each side eight feet wide, and shall be of such height as will permit the free passage of vessels; and if not practical to give said bridge sufficient height to permit the passage of vessels, the Secretary of War is

authorized to have a draw erected in said bridge of suitable dimensions for the accommodation of vessels. And the sum of five hundred thousand dollars, or so much thereof as may be necessary, is hereby appropriated, out of any money in the Treasury not otherwise appropriated, for the purpose of carrying out the foregoing.

The following resolution of the Senate Committee on Public Buildings and Grounds, Fifty-second Congress, April 18, 1892, was referred to the Secretary of War in connection with the bill (S. 796) just quoted:

Resolved by this committee, That the Secretary of War (in connection with S. 796) be requested to have an estimate made of the cost of the bridge proposed to connect the United States Naval Observatory grounds and Arlington estate property, and to suggest his views in reference to the plans and specifications, and submit plan of the proposed bridge, and to state whether a more desirable point for the Washington end of the bridge than the Naval Observatory grounds can be secured.

Maj. C. E. L. B. Davis, Corps of Engineers, to whom this bill was referred by the Chief of Engineers, General Casey, reported, under date of June 1, 1892, that, in his opinion, no more desirable point for the Washington end of the bridge than the Naval Observatory grounds could be secured. He recommended a bridge closely similar to the one proposed by Colonel Hains in 1886, the only change being in the width of wagon way proposed, which was 30 feet instead of 24 feet; the bridge to consist of four spans of about 300 feet each, the second one from the Washington side to be a pivot draw, the trusses to be of steel. The lower chord of the structure to be 28 feet above low tide.

The estimated cost of the bridge and approaches was $803,990.

Bill 9120, House of Representatives, June 6, 1892, Fifty-second Congress, first session, for the construction of a memorial bridge from the Naval Observatory grounds to the Arlington estate, contained the following:

* * * That the Secretary of War is authorized and directed to have constructed a memorial bridge from the most convenient point of the Naval Observatory grounds across the Potomac River to the most convenient point of the Arlington estate property.

SEC. 2. That said bridge shall be of such dimensions and capacity, and constructed of such material as in the judgment of the Secretary of War is most suitable; and if not practical to give said bridge sufficient height to permit the passage of vessels, the Secretary of War is authorized to have suitable mechanical means or draw provided to allow the unobstructed passage of vessels in the channel part of the river; and the sum of one hundred thousand dollars, or so much thereof as may be necessary, is hereby appropriated, out of any money in the Treasury not otherwise appropriated, for the purpose of securing designs and to commence the construction of said bridge.

On the 29th of January, 1895, during the third session Fifty-third Congress, a bill (No. 2673) was introduced in the Senate of the United States, and is as follows:

A BILL To provide for the construction of a bridge across the Potomac River.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of War is hereby authorized and directed to have constructed a bridge from the most convenient point of the Naval Observatory grounds, or adjacent thereto, across the Potomac River to the most convenient point of the Arlington estate property, subject to such regulations as he shall prescribe.

SEC. 2. That the cost of said bridge shall not exceed the sum of six hundred thousand dollars; and the sum of one hundred thousand dollars, or so much thereof as may be necessary, is hereby appropriated, out of any money in the Treasury not otherwise appropriated, for the purpose of securing designs and of commencing the construction of said bridge, which shall be used exclusively for foot passengers and vehicles, and prohibited to all tramways, whether propelled by steam, electric, cable, horse, or other power.

This bill was referred by the Chief of Engineers, General Casey, to Major Davis, Corps of Engineers, for report. Major Davis, in his report, February 2, 1895, upon the bill, wrote:

While the present bill says nothing specific as to the artistic or monumental character of the proposed bridge, the very liberal allotment of $100,000 for the purpose of securing designs and the absolute prohibition of all tramways, whether propelled by steam, electric, cable, horse, or other power, would seem to imply a bridge of the character above specified.

This report, in referring to the recommendation (in 1886) of General Newton for a mixed Board of Engineers to consider plans for such a bridge, says:

If the expenses of such a board are deducted from the $600,000 mentioned in the bill as the extreme limit of the cost of the bridge, as well as the expense attending the competition—for it is doubtful if satisfactory plans could be submitted unless some pecuniary inducement is offered—there would not be enough money left to build even a commercial bridge, and any attempt at an artistic or memorial structure would be out of the question.

He therefore recommended that the words in section 2 of the bill, "the cost of said bridge shall not exceed the sum of six hundred thousand dollars; and" be stricken out.

On December 3, 1895, a bill, identical with the one just quoted, with the exception that it provided for the construction of a memorial bridge, was introduced in the Senate.

None of the foregoing bills became laws.

With two exceptions the designs considered prior to 1897 were for ordinary traffic bridges—that is, bridges not of a memorial character—the superstructures of all the bridges considered, however, to be of iron or steel, the proposed widths of roadways to range from 24 to 40 feet, and the widths proposed for sidewalks each ranging from 8 to 10 feet. The acts or bills under which the designs were considered generally contained provisions in the interest of navigation of the river.

The cost of material and labor upon which the estimates were then based can hardly be satisfactorily compared with the high prices of to-day for most building material, or with the cost of labor of to-day. The demands for bridge capacity of the large and growing city of Washington of to-day are greater than would have been those of ten to fifteen years ago.

The sundry civil act of Congress, approved March 3, 1899 (Public—No. 188), provided in the following words for securing designs for a memorial bridge at Washington:

Memorial bridge across Potomac River: To enable the Chief of Engineers of the Army to continue the examination of the subject and to make or secure designs, calculations, and estimates for a memorial bridge from the most convenient point of the Naval Observatory grounds, or adjacent thereto, across the Potomac River to the most convenient point of the Arlington estate property, the sum of five thousand dollars.

This act does not fix any limit to the cost of the proposed structure, nor does it indicate whether or not electric or other tram cars shall be excluded from it.

The necessity of so planning the proposed bridge as not to materially interfere with the free navigation of the Potomac may be appreciated from examination of the extract given below from the report of 1897, already referred to:

Record of the number of vessels passing the draw of Long Bridge during 1896 and 1897.

Month.	Number of times draw opened.	Number of steam vessels.	Number of sailing vessels.
1896.			
January	215	228	151
February	302	392	256
March	406	441	309
April	633	683	489
May	723	817	679
June	734	843	628
July	667	683	548
August	696	795	654
September	620	627	618
October	557	642	532
November	552	661	448
December	492	570	447
Total	6,597	7,382	5,759
1897.			
January	203	196	131
February	97	103	50
March	296	289	201
April	469	504	404
May	582	638	432
June	658	764	554
July	657	724	556
August	816	967	678
September	670	761	608
October	615	700	589
November	560	630	557
December	471	553	477
Total	6,094	6,829	5,237

Long Bridge crosses the Virginia Channel of the Potomac River at a point about 1½ miles below the crossing for the proposed memorial bridge, the latter being about three-fourths of a mile below the port of Georgetown.

Continuing, the report of the survey of 1897 says of the record of vessels passing Long Bridge:

This record includes all vessels, of whatever size, local as well as foreign, for which the draw had to be swung; and what is of importance to this report, it shows the number of times the draw was opened during each of the years 1896 and 1897.

It must be said, however, in regard to the number of draw openings that, as the clear headroom under the bridge is but 10.3 feet at low-water stage, all craft passing the bridge must go through the draw, small boats excepted.

The record does not give the dimensions or draft of the vessels passing the draw. The elevations of the topmasts of some of the larger class of sail vessels range in height, above the water surface, from 140 to 150 feet, the lengths of the topmasts ranging from 40 to 45 feet. The height of topmast of one of the larger class of vessels lately arriving at this port is, as reported to me, 154½ feet, the length of topmast being 43 feet.

In the report of 1890 upon a bridge to cross the Potomac from a point at or near the foot of New York avenue to Arlington, referred to in the early part of this report, it was proposed to provide a headroom under the bridge of 105 feet, which it was then supposed would allow the largest four-masted schooners to reach Georgetown by lowering their topmasts.

That amount of headroom would fall about 7 feet short of the requirement for the vessel last noted in case her topmasts were lowered. If the headroom referred to the plane of low tide it would be, for average high tide, about 10 feet short of the room needed, so that for a vessel with topmasts as just noted the headroom should be

about 116 feet at low tide. A bridge of, or approximating, such height would be very expensive, besides having the disadvantage of very long approaches.

For vessels to be obliged to lower their topmasts every time they pass a bridge built over navigable waters of the United States is by many regarded as a hardship. Draws of bridges crossing such waters are generally required to be opened with promptness upon signal being given that a boat is about to pass the bridge, yet delays in opening and closing draws sometimes unavoidably occur.

On the other hand, the time consumed in maneuvering the draws of bridges, of highway bridges especially, frequently results in inconvenience to pedestrians and vehicles crossing the bridge.

The record shows that the draw of Long Bridge was opened 6,597 times in 1896. The number of openings for June of that year was 734, that being the greatest number for any one month of that year. The number per day averaged, therefore, nearly 25. In keeping the record of passing boats it appears that all those not propelled by steam were reported under the head of sail vessels, whether they had masts and sails or not. It has been customary to keep the draw closed from about one hour after dark to about one hour before daylight. I am informed that the length of time the average travel over the bridge is stopped by a boat passing the draw is from eight to ten minutes.

With perhaps a few exceptions, all the craft passing Long Bridge would pass the proposed memorial bridge; but if the latter were to afford headroom under its spans of 35 feet above ordinary high tide the tugs, flats, and barges, and other small craft could pass under the bridge, not requiring the draw to open, thus probably reducing the average number of draw openings to five or six per day.

While the suggestion contained in the last paragraph of the preceding quotation, as to the greatly reduced number of openings of a draw that might result from affording clear headroom of 35 feet or more under the channel spans of the bridge, was in the nature of an approximate estimate, it is evident that a liberal extent of headroom beneath the channel spans will largely reduce the daily number of draw openings, and that a still further reduction may be effected through authorized regulations as to the manner of passing the draw, all of which would be in the direction of minimizing interruption of travel across the bridge.

Excessive headroom under the spans, it may be noted, would result in approaches of great length and corresponding expense.

This digression serves to explain in part questions to be considered in preparing a design for a bridge that must necessarily provide for the passage of vessels through or under it and that might also have to admit the passage of electric or other tram cars across it.

Regarding the securing of designs for a memorial bridge under the act of Congress of March 3, 1899, it was decided that the most expeditious and probably the most satisfactory method of carrying out the provisions of that act would be through competition of a limited number of prominent and experienced bridge engineers and designers invited to present designs in accordance with general outline specifications to be drawn up under the supervision of the Engineer Department.

Four such bridge engineers and designers were invited to so compete, viz, Messrs. L. L. Buck, William H. Burr, William R. Hutton, and George S. Morison.

The gentlemen named all accepted the invitation to compete, subject to the specifications accompanying the invitation. These specifications subsequently underwent considerable change, which will be referred to further on.

By the 31st of January the designs had been delivered. With each design was a memoir by the designer explanatory of his proposed structure.

Following is a brief description of the main features of the various designs submitted, the names of the designers arranged in alphabetical order:

DESIGNS BY MR. L. L. BUCK, ASSISTED BY MESSRS. W. H. BREITHAUPT, CONSULTING ENGINEER, AND CARRÈRE & HASTINGS AND WALKER & MORRIS, ARCHITECTS.

DESIGN NO. 1.

This is a design for a single-deck bridge, 80 feet in width between railings, providing for two sidewalks, each 10 feet wide, and a 60-foot roadway, of which a width of 20 feet in the center is for a double-track street railway. The total length of the open work of the bridge proper, to cross the Virginia channel between Potomac Park and Analostan Island, and of the approaches, is about 3,875 feet.

The bridge proper consists, in the order named, of two 100-foot granite arches; one 355-foot steel arch; one steel drawspan having a clear opening of 125 feet; a second 355-foot steel arch, and two more 100-foot granite arches.

The 100-foot span granite arches are circular (segmental), the springing line being 21 feet above low water (mean), the rise 27 feet above the spring, and the radius of the intrados 59 feet 9½ inches. The arch ring and face spandrel walls are of granite throughout, the arch ring being 5 feet thick at the crown and 12 feet 9 inches thick at the spring. The solid spandrel backing of broken stone rests upon the arch ring and supports a 6-inch thick foundation of concrete for the asphalt roadway and granolithic sidewalks.

The 355-foot span steel arches are also circular (segmental), the springing line being 18.8 feet above low water, the rise above the spring 32.26 feet, and the radius of the intrados 504.43 feet. The clear headroom above low water at the crown of these arches is 51 feet. A clear headroom of 49 feet 3 inches is provided under these arches for a width of 50 feet at the center and of 47 feet 3 inches for a width of 100 feet.

There are four 2-hinged steel arch ribs, with the spandrels braced by solid web plates in each span. These ribs carry the floor beams and stringers, which in turn support the buckle-plate foundation for the asphalt roadway and granolithic sidewalk, as above. The sidewalks are mainly supported upon cantilevers from the outer ribs. The depth of the ribs is 7.8 feet at the center and from 41 feet to 39 feet at the ends.

The drawspan consists of two bascule arms supported on trunnions, balanced by a rear extension and lead counterweights. The lower line of the draw when closed is also a circular segment of 107.72 feet radius. The clear opening is 125 feet, the span from center to center of trunnions is 138 feet, and the clear headroom at the center when the draw is closed is 57 feet. The bascule arms are composed of six steel ribs 4 feet 3 inches deep at the center and 21 feet 6 inches deep at the ends, the spandrels being braced by solid web plates, as before. The floor of English cork brick over cinder concrete upon a buckle-plate foundation is supported by these ribs by means of floor beams and stringers. It is proposed to operate the draw by two 50-horsepower electric motors, the time of opening the draw being estimated at one minute or less.

The Washington approach consists, in the order named (beginning at the bridge proper), of five 75-foot granite arches and one 140-foot granite arch, back of which is an earthen embankment about 600 feet long with granite retaining walls.

The 75-foot span granite arches are full semicircular, the springing line being 15 feet 6 inches above low water, the rise above the spring 37 feet 6 inches, and the radius of the intrados 37 feet 6 inches. The arch ring is 3 feet thick at the crown and 5 feet 1 inch thick at the spring.

The 140-foot span granite arches are circular (segmental), the springing line being 21 feet above low water, the rise above the spring 29 feet, and the radius 99 feet. The arch ring is 6 feet thick at the crown and 14 feet thick at the spring. In other respects these arches are similar to the 100-foot span arches already described.

The Arlington approach consists (beginning at the bridge proper) of five 75-foot, one 140-foot, five 75-foot, one 140-foot, and five 75-foot span granite arches, followed by an earthen embankment about 600 feet long with granite retaining walls, and providing a passageway for the Washington Southern Railroad. These arches are similar to those of the Washington approach.

The bascule piers are to be sunk to bed rock by the pneumatic process, the caissons to be filled with Portland-cement concrete. Above the caissons these piers are to be entirely of granite masonry; the foundations of all other piers to be built inside of cofferdams and to consist of Portland-cement concrete from the bed rock up to within 2 feet of low-water mark, or the surface of the ground, as the case may be. Above these points the masonry consists of granite face walls with other suitable stone for backing.

The grades are as follows: Beginning with an elevation of 47 feet above low water, at the intersection of Twenty-third street and New York avenue, there is a rising grade of 1.94 per cent to the first arch; a level stretch at an elevation of 59 feet across Potomac Park; a rising grade of 0.52 per cent to the bascule pier; a level stretch at an elevation of 62 feet across the drawspan; a down grade of 0.52 per cent to the end of the bridge proper; a down grade of 0.08 per cent to the end of the open work; a down grade of 0.48 per cent to the Arlington Plaza (proposed in the design), and a level stretch at an elevation of 55 feet to the Georgetown and Alexandria road. The maximum grade proposed is, hence, 1.94 per cent.

The principal divisions of the bridge are marked by towers and massive points of masonry, surmounted by allegorical groups of sculpture and surrounded by symbolical figures, etc. Upon the bascule piers are erected four massive masonry towers, forming the culminating point of the design.

The total estimated cost of the structure is $16,434,230 if the bridge and approaches be finished in 6-cut masonry, or $15,409,000 if finished in rock-face masonry.

DESIGN NO. 2.

This design is identical in every respect with Mr. Buck's design No. 1, except that no provision is made for street-railway tracks, the width of roadway being reduced to 40 feet and the total width between railings to 60 feet.

The total estimated cost of this structure is $14,735,400 if the bridge and approaches be finished in 6-cut masonry, or $13,940,000 if finished in rock-face masonry.

DESIGNS BY MR. WILLIAM H. BURR, ASSISTED BY MR. EDWARD P. CASEY, ARCHITECT.

DESIGN NO. 1.

This is a design for a double-deck bridge 60 feet in width between railings. Two sidewalks, each 10 feet wide, and a roadway 40 feet wide are carried upon the upper deck, while a double-track street railway is provided for upon the lower deck. The total length of the open work of the bridge proper and approaches is about 3,440 feet.

The bridge proper consists of two 283-foot span steel arches, one steel draw span having a clear span of 213 feet, and two more 283-foot steel arches.

The 283-foot steel arches are circular (segmental), the springing line being 24 feet above mean low water, the rise 26 feet above the spring, and the radius of the intrados about 400 feet. The clear headroom under the crown of the arches is 50 feet. A clear headroom of about 48 feet 9 inches is provided under these arches for a width of 50 feet at the center and about 36 feet 3 inches for a width of 100 feet.

There are five 2-hinged, solid web steel arch ribs, 10 feet in depth, with spandrels of open steel construction in each span. These ribs and spandrel posts carry the floor beams and stringers, which in turn support the buckle-plate foundation for the asphalt roadway and granolithic sidewalk of the upper deck and the ties of the street railroad of the lower deck.

The drawspan is composed of 2 bascule arms supported on trunnions, balanced by rear extensions and counterweights. The clear opening is about 167 feet, the clear span at low-water level 213 feet, and the span from center to center of trunnions 225 feet 11½ inches. The bascule arms are composed of 5 steel ribs or trusses, of the lattice girder type, with parallel chords, 15 feet deep over all. The clear headroom is about 50 feet when the draw is closed. The floor is to be of asphalt cork blocks molded to fit the buckle plates, which are supported as above, or alternatively of prepared wood. It is proposed to operate the draw by four 50-horsepower electric motors.

The Washington approach consists of 15 46-foot masonry arches, back of which is an earthen embankment about 500 feet long.

The 46-foot span masonry arches are full semicircular, the springing line being 24 feet above low water, the rise above the spring 23 feet, and the radius of the intrados 23 feet. The face of the arch ring is of granite, but the main part of the ring is constructed on the Melan system of combined concrete and steel, there being 5 main concrete steel ribs. The granite arch ring is 3 feet deep throughout, while the concrete and steel ribs are 20½ inches deep at the crown and 49 inches deep at the spring. A masonry spandrel wall, partly of granite and partly of concrete, provided with circular openings to admit light and air to the lower deck, rests upon the granite arch rings. The asphalt roadway and granolithic sidewalks are supported by concrete floor arches between I-beams. The weight of this floor system, together with that for the street railway on the lower deck, is carried

down to the arch ring by framed steel posts between the above masonry spandrel walls.

The Arlington approach consists of 21 46-foot masonry arches, identical with those composing the Washington approach, back of which is about 1,500 linear feet of earth embankment.

The two bascule piers and the adjacent piers between the 283-foot steel spans are to be built on bed rock by the pneumatic process, the caissons to be filled with concrete. The other piers are also to be founded upon bed rock and built up within cofferdams. The facing of all piers is to be granite and the interior concrete. The shore piers of the river spans and all the piers of the approaches and of the abutments are pierced with arches whose axes are parallel to the axis of the structure. These arches have spans of 24 or 28 feet, and their springing lines are at the elevation of low water. They are inserted for purposes of economy. The combination of steel with concrete is used in the piers as well as in the arches.

The grades of the upper roadway are as follows: Beginning with an elevation of about 45 feet at the intersection of Twenty-third street and New York avenue, there is a rising grade of 2 per cent to the first arch, from which point the grade is level at an elevation of 65 feet to the end of the open work on the Arlington side, whence it falls, upon a slight grade, to the Georgetown and Alexandria road. The maximum grade proposed is 2 per cent.

The principal divisions of the bridge are marked by massive masonry arches and towers, decorated with emblematic groups of statuary, etc. Upon each of the bascule piers is erected a single arch, transverse with the roadway, constituting the most prominent decorative feature of the bridge.

The total estimated cost of the structure is $4,083,855.

DESIGN NO. 2.

This is a design for a single-deck bridge 60 feet in width between railings, providing for two sidewalks, each 10 feet wide, and a roadway 40 feet wide. This design makes no provision for street-railway tracks. The total length of the open work of the bridge proper and approaches is about 3,400 feet.

The bridge proper is to consist of three 192-foot span masonry arches, one steel draw span having a clear width of 159 feet, and three more 192-foot span masonry arches.

The 192-foot masonry arches are circular (segmental), the springing line being 24 feet above mean low water, the rise above the spring 29 feet, and the radius of the intrados 173.8 feet.

The clear headroom under the crown of the arch is 53 feet. A clear headroom of about 51 feet at low water is provided under these arches for a width of 50 feet at the center and of about 45 feet 4 inches for a width of 100 feet. The face of the arch ring is of granite, but the construction of the main part of the ring is on the Melan system, there being 5 main concrete steel ribs. The granite arch ring is 5 feet 6 inches deep at the crown and 9 feet 6 inches deep at the spring, while the concrete steel ribs are 30 inches deep at the crown and 7 feet 3 inches at the spring. A solid masonry spandrel wall, partly of granite and partly of concrete, rests upon the granite arch ring. The asphalt roadway and granolithic sidewalks are supported by concrete floor

arches between I-beams. The weight of this floor system is carried down to the arch ring by framed steel posts between the above masonry spandrel walls.

The drawspan has 2 bascule arms supported on trunnions, balanced by rear extensions and counterweights. The clear opening is about 135 feet; the clear span at low water level 159 feet, and the span from center to center of trunnions 170 feet. The bascule arms are composed of 5 steel trusses of the lattice-girder type, with parallel chords 12 feet 6 inches deep between centers. The clear headroom is about 51 feet when the draw is closed. The floor is to be of asphalt cork blocks, molded to fit the buckle plates, which are supported by the floor beams and stringers carried by the trusses. It is proposed to operate the draw by four 50-horsepower electric motors.

The Washington approach is to consist of twelve 60-foot span masonry arches, back of which is an earthen embankment about 550 feet long.

The 60-foot span masonry arches are full semicircular, the springing line being 24 feet above low water, the rise above the spring 30 feet, and the radius of the intrados 30 feet. The arch is constructed of the same materials and in the same manner as the 192-foot masonry arch above described. The granite arch ring is four feet deep throughout, while the concrete and steel ribs are 16 inches deep at the crown and 48 inches deep at the spring.

The Arlington approach will consist of fifteen 60-foot masonry arches, identical with those composing the Washington approach, back of which is about 1,350 linear feet of earth embankment.

The piers and their foundations are similar to those of design No. 1, the 6 masonry piers in the river being on caissons, and the remainder inside cofferdams.

The grades proposed are identical with those of design No. 1, and the decorative features are similar, the single arch at the bascule piers being replaced by a series of 3 arches, the larger over the roadway and the 2 smaller over the sidewalks.

The total estimated cost of this structure is $3,680,672.

DESIGN NO. 3.

This is a design for a double-deck bridge 60 feet in width between railings. Two sidewalks, each 10 feet wide, and a roadway 40 feet wide, are carried upon the upper deck, while a double-track street railway is provided for upon the lower deck. The total length of the open work of the bridge proper and approaches is about 3,470 feet.

The bridge proper consists of two 283-foot span masonry arches, 1 steel drawspan having a clear width of 213 feet, and 2 more 283-foot masonry arches.

The 283-foot masonry arches have semielliptical soffits, the springing line being 4 feet above low water and the rise 70 feet 9 inches above the spring. (In this ellipse, as in all others in this design, the major axis is twice the transverse.) There is a clear headroom of 74 feet 9 inches under the crown, a clear headroom of about 72 feet 9 inches for a width of 50 feet at the center, and of about 69 feet 3 inches for a width of 100 feet. The face of the arch ring is of granite, but the main part of the ring is constructed on the Melan system, there being 5 main concrete steel ribs. The granite arch ring and the concrete steel ribs are

both 8 feet deep at the crown and 23 feet deep at the spring. A masonry spandrel wall, partly of granite and partly of concrete, provided with arched openings to admit light and air to the lower deck, rests upon the granite arch rings. The asphalt roadway and granolithic sidewalks are supported by concrete floor arches between I-beams. The weight of this floor system together with that for the street railway on the lower deck is carried down to the arch ring by framed steel posts between the masonry spandrel walls.

The drawspan is identical with that of design No. 1, except that the height of the lower chord above low water is about 75 feet when the draw is closed.

The Washington approach is composed of five semielliptical masonry arches, back of which is an earthen embankment about 550 feet long. These arches, which are constructed of the same materials and in the same manner as the 283-foot masonry arch above described, have spans (beginning at the bridge proper) of 190, 170, 153, 137, and 123 feet, respectively. The elevation of the springing line of all these arches is 24 feet above low water, and, as previously stated, the rise above the spring is one-fourth of the span.

The Arlington approach is composed of seven similar aches of 190, 170, 153, 137, 123, 110, and 99 feet, respectively, in the order named, beginning at the bridge proper. Back of this is an earthen embankment about 1,500 feet long.

The piers and their foundations and the decorative features are similar to those of design No. 1.

The grades of the upper roadway are as follows: Beginning with an elevation of about 56 feet at the intersection of Twenty-third street and New York avenue, there is a rising grade of 2½ per cent to the bridge proper, a level stretch across the bridge proper at an elevation of 91 feet, and a falling grade of 2½ per cent to an elevation of about 64.5 feet at the Arlington end of the open work. The maximum grade is hence 2½ per cent.

The total estimated cost of the structure is $4,480,224.

DESIGNS BY MR. W. R. HUTTON, ASSISTED BY MR. ERNEST FLAGG, ARCHITECT.

DESIGN NO. 1.

This is a design for a double-deck bridge 60 feet in width between the railings. Two sidewalks, each 10 feet wide, and a roadway 40 feet wide are carried upon the upper deck, while a double-track street railway is provided for upon the lower deck. The total length of the open work of the bridge proper and approaches is about 3,900 feet.

The bridge proper consists, in the order named, of one 550-foot steel arch, one steel drawspan having a clear opening of 126 feet, and a second 550-foot steel arch.

The 550-foot span steel arches are circular (segmental), the springing line being about 24 feet above mean low water and the rise about 37 feet above the spring. There is a headroom of about 61 feet at the crown of these arches, a clear headroom of about 60 feet for a width of 50 feet at the center, about 59 feet for a width of 100 feet. There are seven 2-hinged, solid web, steel arch ribs 8 feet 5 inches in depth, with spandrels of open steel construction in each span. These ribs and

spandrel posts carry the floor beams and stringers, which in turn support the buckle-plate foundation for the asphalt roadway and granolithic sidewalks of the upper deck and the railway floor system for the lower deck.

The drawspan is of the vertical lift type, affording a clear opening of 126 feet. It is composed of 5 steel trusses with parallel chords, and is about 20 feet deep. The clear headroom under the lower chord is about 64 feet at low water when the draw is closed and about 135 feet when open. The floor system is the same as for the 550-foot arch just described. The span is counterweighted by blocks of cast iron attached by steel cables, passing over sheaves at the top of the towers, to the corners of the span. It is to be operated by two 60-horsepower electric motors.

The Washington approach consists of 6 masonry arches, each having a span of about 100 feet, back of which is an embankment about 600 feet long.

These masonry arches are elliptical, the springing line being from 17 to 22 feet above low water and the rise about 30 feet above the spring. The arch ring is of granite and the entire exterior faced with the same, concrete being used behind the facing. The arch ring is about 4 feet deep at the crown and about 7 feet deep at one-half the rise. The exterior walls of the subway are an arcade of small granite arches. The interior wall and other spandrel walls supporting the roadway are of brick. The asphalt roadway and granolithic side walks are laid upon a leveling bed of concrete, the weight being transferred to the above brick spandrel walls by brick arches, except over the subway, where the length of the span necessitates the use of embedded steel I-beams as supports. The space under the street-railway tracks is filled with "sand-béton," covered with 3 or 4 feet of earth for laying tracks. The five arches adjoining the bridge proper are right arches, while the one adjoining the embankment spans Water street and is designed upon a skew. The wide pier caused by the obliquity of the arch is designed to contain a stairway giving access from the bridge to Potomac Park.

The Arlington approach consists (beginning at the bridge proper) of six 100-foot masonry arches and four 200-foot steel arches, behind which is an embankment about 500 feet long (including three small arches).

The 100-foot masonry arches are identical with the right arches of the Washington approach.

The 200-foot steel arches are circular (segmental), the springing line being about 24 feet above low water, the rise about 20 feet above the spring, and the radius of the intrados about 235 feet. There are five 2-hinged, solid web, steel arch ribs about 4 feet in depth, with spandrels of open steel construction in each span. The floor systems are as in the 550-foot arches.

The draw piers are designed to be founded on four pneumatic caissons, two to each pier, and the other piers inside of cofferdams, all resting on bed rock. They are to be constructed entirely of concrete to within a few feet of the surface, above which they are to be faced with stone.

The grades of the upper roadway are as follows: Beginning at an elevation of 60 feet above low water at the intersection of Twenty-third street with New York avenue, the grade rises to an elevation of

88 feet at the draw and then falls on a uniform light grade to the Georgetown and Alexandria road at Arlington. The maximum grade proposed is 1½ per cent.

Upon the draw piers are erected four massive towers, connected at the top by a large steel dome over the draw opening. The cut waters of the piers are highly decorated, and the approaches to the main steel arches are flanked by masonry towers, crowned with groups of sculpture, etc.

The total estimated cost of the structure is $9,954,510.

DESIGN NO. 2.

This is a design for a single-deck bridge 60 feet in width between railings, providing for two sidewalks, each 10 feet wide, and a roadway 40 feet wide. This design makes no provision for street railway tracks. The total length of the open work of the bridge proper and approaches is about 4,000 feet.

The bridge proper consists of two 272-foot steel arches, one steel drawspan having a clear opening of 134 feet, and two more 272-foot steel arches.

The 272-foot steel arches are circular (segmental), the springing line being about 20 feet above mean low water, the rise above the spring about 35 feet, and the radius of the intrados about 325 feet. There is a clear space of about 55 feet under the crown of the arches, a clear headroom of about 54 feet for a width of 50 feet at the center, and of about 51 feet for a width of 100 feet. There are five 2-hinged, solid web, steel-arch ribs, about 6 feet deep, with spandrels of open steel construction in each span. These ribs and spandrel posts carry the floor beams and stringers, which in turn support the buckle plate foundation for the asphalt roadway and granolithic sidewalks.

The drawspan is a double-leaved bascule roller lift bridge, after the patent of Mr. Montgomery Waddell, in which the counterbalanced half span rests and moves upon a certain number of large fixed friction rollers. The clear opening is 134 feet. The bascule arms are composed of 5 steel ribs or trusses, with a curved lower chord, giving an arched appearance when closed. A wooden block pavement is proposed, which is supported by these ribs, by the aid of steel floor beams and stringers. It is proposed to operate the draw by two 50-horsepower electric motors.

The Washington approach consists of six masonry arches, of which the last one crosses Water street and is a skew arch. The arches are elliptical, the span being about 105 feet, the springing line from 13 to 17 feet above low water, and the rise about 36 feet above the spring. The construction of these arches is similar to those of design No. 1, except that all provision for the subway is omitted and the roadway is supported upon a backing which rests directly upon the arch ring and is contained by two heavy face spandrel walls acting as retaining walls.

The Arlington approach consists (beginning at the bridge proper) of six masonry arches and four 204-foot span steel arches.

The masonry arches are identical with those of the Washington approach.

The 204-foot steel arches are circular (segmental), the springing line being from 20 to 25 feet above low water, the rise above the spring about 20 feet, and the radius of the intrados about 200 feet. There are five

2-hinged, solid web, steel ribs, about 4 feet in depth, with spandrels of open steel construction in each span. The floor systems are as in the 272-foot steel arches.

The piers are probably to be similar to those in design No. 1, and similarly founded.

Grades are not stated.

The principal divisions of the bridge are marked by ornamental masonry towers, of which the largest are on the bascule piers

The total estimated cost of the structure is $5,750,000.

DESIGNS BY MR. GEORGE S. MORISON, ASSISTED BY MESSRS. WILLIAM EMERSON, ARCHITECT, AND W. F. SMITH, ASSISTANT ENGINEER.

DESIGN NO. 1.

This is a design for a single-deck bridge 80 feet in width between railings, providing for two sidewalks, each 10 feet wide, and a 60-foot roadway, of which 10 feet on each side, adjacent to the sidewalks, is for street railway tracks. The total length of the open work of the bridge proper and the approaches is about 4,020 feet.

The bridge proper consists of five masonry arches. The span of the central arch is 182.78 feet, the spans of the 2 adjacent to it are 181.38 feet, and of the end ones 177.22 feet each.

The 182.78-foot span masonry arch is circular (segmental), the springing line being 13.7 feet (about the maximum freshet height recorded) above mean low water, the rise 45.7 feet above the spring, and the radius of the intrados 114.24 feet. The clear height under the crown of the arch is about 59.4 feet; there is clear headroom of about 56 feet for a width of 50 feet at the center and of about 48 feet for a width of 100 feet. The arch ring and face spandrel walls are of limestone, the arch ring being 5 feet deep at the crown and 7 feet deep at the spring. The spandrels are pierced transversely by a series of 8 small semi circular arches, supported on piers 4 feet thick, resting upon the arch ring. These spandrel arches support a leveling bed of concrete, upon which is laid the granolithic sidewalks and a course of gravel 2 feet thick underlying the asphalt roadway. Provision is made for electric subways, drainage, etc.

The other arches of the bridge proper are similar to the central arch.

The piers and abutments of the bridge proper are to be built upon bed rock by means of pneumatic caissons. It is proposed to have the piers of limestone, with a granite facing commencing about 3 feet below low water. The abutments to be of solid concrete, faced with limestone and granite, as above.

The decorative features consist mainly of four columns, each terminated by a globe surmounted by a bronze eagle, placed upon the abutments, and a bronze eagle at the crown of the central arch, together with ornamental construction for railing, cornices, etc., of the bridge proper. The monumental element has been dropped in the other parts of the design.

Two drawspans are provided, one at each end of the bridge proper, each affording a clear opening of 64 feet. The spans are single leaf, deck, Scherzer rolling lift drawbridges, and consist of 4 steel trusses, carrying the floor beams and stringers, which in turn support the buckle plate foundation and leveling bed of concrete for the asphalt

roadways and granolithic sidewalks. These draws open away from the bridge proper, and rest upon limestone piers founded on pneumatic caissons. The present depth at the site of the proposed draws being very slight, the designer proposed to dredge channels leading to them.

The approaches consist in general of skeleton steel viaducts. The asphalt roadway and granolithic sidewalks rest upon a foundation of concrete on buckle plates, which are supported upon solid web, steel floor beams and stringers, which rest in alternating spans of 32.83 and 29.17 feet upon bents consisting of three vertical steel posts. Each post is supported on a concrete pier capped with granite and resting upon 12 piles driven to rock. The sidewalks are supported on cantilevers. The only exception to this general type of approach is at Water street, on the Washington side, which is crossed by a deck Pratt truss steel bridge of 160 feet of span resting on masonry piers. This bridge is of eight panels, about 20 feet depth, and carries a roadway similar to that of the remainder of the approach. The viaducts each terminate in a masonry abutment, beyond which are earth embankments about 450 and 1,000 feet long in the Washington and Arlington approaches, respectively.

The grades are as follows: Beginning with an elevation of 45.15 feet above low water at the intersection of Twenty-third street and New York avenue, there is a rising grade of 1.3 per cent to the face of the first arch of the bridge proper, where the elevation is 65.45, thence on a vertical curve across the bridge proper, the highest point, at the center of the structure, being at an elevation of 68.7 feet, and the elevation at the face of the last arch being (65.45) as before, thence on a falling grade of 1.3 per cent across the draw opening and then on a falling vertical curve across the Little River Flats to an elevation of about 50 feet at the Arlington abutment. The maximum grade proposed is 1.3 per cent.

The total estimated cost of the structure is $2,757,264.[1]

DESIGN NO. 2.

This design is practically identical in every respect with Mr. Morison's design No. 1, except that, as no provision is made for street-railway tracks, the width of the roadway is reduced to 40 feet and total width between railings to 60 feet.

The total estimated cost of this structure is $2,170,425.

For full description and discussion of the designs reference is made to copies of the memoirs of the several designers accompanying this report.

A decision as to the order of merit of designs presented by the distinguished engineer competitors, assisted by distinguished architects, necessarily required much consideration and work on the part of the Board.

The general outline specifications governing the competition, issued under date of July 21, 1899, called for the presentation of two designs for a bridge with a draw opening; one design to provide for street cars as well as for ordinary vehicles and for pedestrians, the street cars to

[1] Mr. Morison also suggests the entire omission of the draws, and the substitution of an earth embankment for the open approaches. These modifications applied to the above design would reduce his estimated cost to $2,084,500.

be below (underneath) the highway. The width of the structure to be 60 feet, including sidewalks. Materials mainly granite and steel. The second (alternate) design to be for a bridge with draw opening, but without provision for street cars.

The question whether street cars should be allowed upon the bridge being an important one and admitting of considerable difference in opinion, it was deemed best that designs should be submitted for each kind of bridge, in order to a better comparison of their architectural effect, adaptability, and cost, respectively.

The designs and drawings were to be submitted by January 16, 1900, to be paid for, in the order of merit of the designs, as recommended by a Board of Engineers and Architects and approved by the Secretary of War, as follows:

For No. 1	$1,200
For No. 2	1,100
For No. 3	1,000
For No. 4	900

The designs, drawings, and estimates were then to become the property of the United States.

The requirements of the specifications were subsequently changed so as to allow such of the competitors as desired to do so to make the principal design for a bridge without provision for street cars; the provision for such cars to be shown upon the second, or subordinate, design, and also to select the material they proposed to use in construction, as well as to modify the proposed widths for roadway, etc. The date for presentation of the designs was extended to January 31.

The estimates of the cost of the proposed designs are tabulated as follows:

Name.	Design No.	Width, feet.	Decks, No.	Bridge proper, except steel draw.	Approaches.	Cost.
Mr. Buck	1	80	1	Steel and 6-cut masonry.	6-cut masonry	$16,434,230
	2	60	1	do	do	14,735,400
	1	80	1	Steel and rock-face masonry.	Rock-face masonry.	15,409,000
	2	60	1	do	do	13,940,000
Mr. Burr	1	60	2	Steel	Melan	4,083,850
	2	60	1	Melan	do	3,680,672
	3	60	2	do	do	4,480,224
Mr. Hutton	1	60	2	Steel	Masonry and steel	9,954,510
	2	60	1	do	do	5,750,000
Mr. Morison	1	80	1	Masonry	Steel	2,757,264
	2	60	1	do	do	2,170,425
	1	80	1	Masonry (no draw).	Earth	2,084,500

The low price of Mr. Morison's estimates is evidently largely due to the skeleton steel construction for the approaches, the absence of massive towers and decorative features, and the use of limestone in the arches.

The fact that Mr. Burr's estimates are lower than the others of similar character is mainly accounted for by the use of the Melan system, supplemented by structural steel spandrel work, and the greater length of the earthen embankment on the Arlington approach.

Mr. Hutton's estimates are readily accounted for by the materials proposed and the decorative features used.

The high amount of Mr. Buck's estimates is evidently largely due to the amount and character of the decorative work and the fact that granite masonry is so largely proposed.

A complete comparison of the unit prices for materials in place, adopted by the various competitors, is very difficult to make, on account of the differences in the materials and grades of the same required by the various designs, and the different methods of estimating employed; e. g., materials like sand béton, cork brick paving, etc., are found in but one estimate; again, three different grades of concrete, four distinct grades of the same general class of masonry, etc., are frequently met with in the same estimate; some of the estimates include the cost of false works in the price for the arches; the cost of engineering and superintendence is included in the items in some of the estimates, whereas in others such items are given separately.

A tabulation and general comparison of these prices with each other and with those employed in this office has been made and no important differences have been noted.

It goes without saying that each of the estimates, based upon the competitor's own method of estimating, is accepted as correct, the analysis of the same by the Board being only for the purpose of making comparisons.

After full consideration of the various plans for the proposed bridge and approaches, including the architectural features, ornamentation, and cost, the Board places the comparative merits of the design as follows:

No. 1. Design No. 2 of Mr. William H. Burr,
No. 2. Design No. 2 of Mr. William R. Hutton,
No. 3. Design No. 1 of Mr. L. L. Buck,
No. 4. Design No. 1 of Mr. George S. Morison,

and recommends that the sums pertaining to the several awards as to order of merit be paid to the respective competitors.

While it would be desirable, in the abstract, to exclude street cars from a bridge to be erected as a memorial, the Board recognizes the advantage and probable necessity to the locality of a provision for such cars. With this in view, the width of roadway proposed by the board, and upon which the tracks are to be laid, is not less than 60 feet, the sidewalks, bordering the roadway, to be each not less than 12 feet wide, making the total width, between railings, not less than 84 feet.

In the opinion of the Board a steel bascule draw for this bridge is preferable to a swing or an ordinary vertical lift draw, and the substitution of a curve instead of a right line for the lowest part of the draw is regarded as desirable. The bascule form is provided for in design No. 2.

Referring to the use of steel and concrete combined in construction, the board does not favor the use of concealed iron or steel work that requires painting or other similar application for its preservation. It is claimed, however, especially by advocates of the Melan system, that steel well embedded in hydraulic cement concrete or properly coated with the same is practically imperishable, and advocates of that and other similar methods of combining iron or steel and concrete in construction have adduced as arguments many observations as to such preservation of iron or steel that had been embedded in or coated with concrete for a long term of years. A large number of bridges have been built within the past few years on the Melan or similar system (concrete and steel combined), though the longest arch span in this country, of which the board has definite information, that is built on that system is one of 125 feet. Professor Burr's plan No. 2, which

is here placed No. 1 in the order of merit, to be constructed on the Melan system, proposes spans as great as 192 feet.

As to the grade for the roadway, the Board is of the opinion that it should rise slightly toward the crown of the bridge, and that the initial point of the approach, at the intersection of Twenty-third street and New York avenue, should be at an elevation (reference) of about 55 referred to the United States Engineer datum (mean low water of the Potomac). Also, that while the design No. 2 of Mr. Burr is regarded as the most suitable and the best, the general treatment of the towers, especially at the draw, of Mr. Burr's plan No. 1 is regarded as preferable to that of his No. 2.

The Board is of the opinion that the general design of Mr. Burr designated as the first in the order of merit meets the conditions of the problem, and should be adopted, subject to the recommendations and modifications herein set forth as to width, slope of roadway, curve of under side of draw, towers, provision for tram cars, elevation of initial point, etc., and such other minor modifications as experience may suggest upon the undertaking of the work or during its progress.

The modifications recommended will, it is estimated, add about 32 per cent to the original estimate for the said design No. 2 of Mr. Burr, bringing it up to about $4,860,000.

With this report are nine photographs[1] of the various designs.

Respectfully submitted.

Chas J. Allen,
Lieut. Col. Corps of Engineers.
Thomas W. Symons,
Major, Corps of Engineers.
D. D. Gaillard,
Captain, Corps of Engineers.
Stanford White.
Jas. G. Hill.

Hon. Elihu Root,
Secretary of War.
(Through the Chief of Engineers, U. S. A.)

Thirteen inclosures, viz., 4 copies of memoirs and 9 photographs, as follows:

Photograph number.	Character.	Number of design.	Designer.
1	Perspective	1	Buck.
2	do	1	Burr.
3	do	2	Do.
4	Plans 192-foot masonry arches	2	Do.
5	Plans 60-foot masonry arches	2	Do.
6	Perspective	3	Do.
7	do	1	Hutton.
8	Side elevation	2	Do.
9	Perspective	1	Morison.

MEMOIR SUBMITTED WITH THE DESIGNS OF MR. L. L. BUCK.

Manhattan, New York, *January 29, 1900.*

Sir: In compliance with your letters of July 21, 1899, and subsequent dates, and the accompanying maps and profiles, I have, with the cooperation of William H. Breithaupt, esq., consulting engineer, and Messrs. Carrère & Hastings and Messrs. Walker & Morris, architects, prepared two designs for the proposed memorial bridge across the Potomac River at Washington, which are submitted herewith, together with specifications and estimates of cost therefor. One design is for a bridge 80 feet

[1] Not reprinted. Printed in House Doc. No. 578, Fifty-sixth Congress, first session.

in width between railings, with a 60-foot roadway, carrying two street-railway tracks in the middle; the other is for a bridge 60 feet in width between the railings, with a 40-foot roadway, without street-railway tracks. The following seventeen drawings are submitted with and illustrate these designs:

Sheet No. 1.—Map showing location of bridge and proposed changes in streets, etc., at approaches.

Sheet No. 2.—General elevation and plan.

Sheet No. 3.—Washington abutment.

Sheet No. 4.—75-foot arches. Longitudinal elevation and sections.

Sheet No. 5.—75-foot arches. Transverse section, 60-foot roadway.

Sheet No. 6.—75-foot arches. Transverse section, 40-foot roadway.

Sheet No. 7.—140-foot arches. Longitudinal elevation and sections.

Sheet No. 8.—140-foot arches. Transverse section, 60-foot roadway.

Sheet No. 9.—140-foot arches. Transverse section, 40-foot roadway.

Sheet No. 10.—100-foot arches. Longitudinal elevation and section.

Sheet No. 11.—100-foot arches. Transverse section, 60-foot roadway.

Sheet No. 12.—100-foot arches. Transverse section, 40-foot roadway.

Sheet No. 13.—Stress sheets: 75-foot, 140-foot, and 100-foot arches, and piers 10 and 11.

Sheet No. 14.—355-foot arches. General drawing and details.

Sheet No. 15.—Draw span. General drawing and details.

Sheet No. 16.—Stress sheets; 355-foot arch. Stress sheets and operating diagram; drawspan.

Sheet No. 17.—Perspective.

The longitudinal elevation is the same for both designs. Stress sheets are shown only for the design with street-railway tracks. For the alternate design the estimate is based, as to the masonry construction, on the same longitudinal section as for the wider bridge. For the steel spans of the alternate design the assumed live load is the same as for the portion of the wider bridge outside the railway tracks.

In making these designs my associates and I have endeavored to plan a structure, monumental in character, that shall be a fitting memorial to American patriotism. With this aim in view wide scope has been given to architectural features and liberal provision has been made for future sculptural adornment of a memorial type. The designs contemplate three series of masonry arches for the approaches and short river spans, steel arches for the long river spans and the draw, and earth embankments between retaining walls toward the ends of the approaches. All arches are segments of circles in outline. The scheme of the arches is determined by the topography of the ground as indicated on the profile furnished by you and frankly marks the waterways, river proper, and roadways which the bridge is to cross. This scheme also furnishes the key to the decorative treatment of the designs.

I have devoted considerable study to the problem of designing a double-deck bridge, with provision for street cars on the lower deck. The result led me to believe that a single-deck bridge will be more readily adapted to the physical features of the site and the approaches, and more in harmony with the surroundings. The latter form greatly simplifies the treatment of the approaches, and undoubtedly enhances the beauty of the structure as a whole. To make a double row of masonry arches effective, for example, it seems to me that the shores of the stream should be steep, bold, and rugged in contour. I see no reason why trolley cars should not go on the same level with other vehicles that does not apply with equal force to every wide, handsome thoroughfare where provision for cars has to be made. Again, a width of 80 feet, which is none too narrow for a bridge of this length and importance, makes it possible to provide for cars on the same level. On the whole, I determined that a single-deck design would be more satisfactory, and, in accordance with your letter of November 6, 1899, have proceeded on this theory.

The bridge proper has been studied as a monument to the nation at large. Its chief divisions are marked by arched towers and massive points of masonry, surmounted by allegorical groups of sculpture and surrounded by symbolical figures and by tablets and commemorative inscriptions. By thus massing the important features of the bridge a silhouette thought to be pleasing has been obtained, which will count from a distance. The culminating point of the whole design at the draw span may be taken to typify the union of the whole nation—North, South, East, and West. Leading up to the central arches the different States may be symbolized by their coats of arms or other suitable emblems carved in the masonry under the bronze columns, which serve for lighting purposes.

The designs contemplate that dignified and spacious plazas will be provided at the ends of the bridge, where fitting monuments to individuals and statuary can be

placed and where they can be most readily seen by people crossing the bridge. At the center of the Washington plaza is a triumphal column surmounted by a figure of Victory, flanked by four lions or other suitable figures and war trophies. Attention is called to the fact that this column is the point to which all the principal streets leading to the bridge converge and marks the change in axis between New York avenue and the bridge. To add further to the effectiveness of this plaza, it is suggested that the property indicated on the map should be included in the Potomac Park. Comparison of sheet No. 1 with print A will show the proposed changes in the streets in this vicinity. The northwesterly portion of the plaza will require the cutting away and regrading of a portion of Observatory Hill. From the plaza to station 6 plus 57 there is an embankment with retaining walls. The first opening in the Washington approach is a 140-foot arch crossing South Water street, which it is proposed to diverge slightly from its present line at this place. Continuing across the Potomac Park there are five 75-foot arches, which complete the Washington approach.

In general character the Washington approach does not differ materially from the Arlington approach; both will be finished in hammer-dressed masonry surfaces throughout, or with the spandrels of the arches and the outer face walls between the pilasters rough hammer-dressed, and the other surface rock-faced as may be determined. The starling projections of the piers can serve as pedestals for statuary. The 75-foot arches have purposely been made open in construction, so as not to obstruct the view of the river from different points in the park. In order further to enrich the Washington approach the natural topography of the park has been taken advantage of in a series of terraces, each defined by a retaining wall and balustrade, indicated on the general elevation, sheet No. 2. This treatment is thought to be a more logical and artistic method of emphasizing the importance of the Washington approach than would be the introduction of a new motive into the bridge proper, as would otherwise be required.

It has been suggested that, inasmuch as this bridge is to be a memorial to American patriotism, the sculptural adornment of the central portion may well be furnished by the nation at large, and the individual statues and monuments for the plazas and approaches by the different States and municipalities; and that the structure may also appeal to the generosity of public-spirited citizens and patrons of art.

The bridge proper consists, in the order named, of two 100-foot granite arches, one 355-foot steel arch, a steel draw span having a clear opening of 125 feet, a second 355-foot steel arch, and two more 100-foot granite arches. The first 100-foot arch at the Washington end spans a projected roadway along the river front. This roadway is to be carried on an embankment 14 feet above tide level, protected by a sea wall 3½ feet higher, thus forming a levee to exclude the flood waters of the river from the park, which it is proposed to leave at its present level of about 9 feet above low tide.

The 355-foot spans, sheet No. 14, are 2-hinged arches with the spandrels braced by web plates. This form of braced arch has been chosen on account of its superior stiffness over a 3-hinged arch, and because it is thought to harmonize with and carry out the substantial character of the masonry arches. There are four ribs in two pairs, spaced well apart. Floor beams and stringers carry the buckle-plate floor. These spans are on gradients; the centers of the end pins are at the same elevation, and the upper chords are parallel to the grade line, which causes a slight difference in stresses between the two halves of the arch. This difference is not enough to require any variation in make-up. The very considerable thrust of these long arches, with no opposing thrust on the drawspan side, necessitates the large center piers, Nos. 10 and 11. In order to get as large a versed sine as practicable, the pins of the 355-foot arches are placed at an elevation 5½ feet above extreme high water, which the bases of the skew-back pedestals just clear. At the center of the spans there is a clear height of 49.8 feet above low water, for a width of 195 feet under each span there is a clear height of 40 feet, and for a width of 320 feet the clear height is 24 feet. The center of the drawspan when closed is 57 feet above low water in the clear, and at the ends its clearance is 41 feet.

The drawspan, sheet No. 15, consists of two bascule arms supported on trunnions, and is a 3-hinged arch when closed. The dead weight of each arm, except 5,000 pounds for each at the center, is balanced by a rear extension and counterweight so proportioned that its trunnion is at the center of gravity. To insure a better disposition of the counterweights and of the pressure on the masonry, six ribs are used. At the center one arm is convex and the other is V-shaped in outline. The convex end carries a central roller and a pin which comes to a bearing in the concave end. The roller drops into a recess in the concave end when the pin takes its bearing. In closing the draw there is a position, as shown on the drawing, to which

either arm can come without interfering with the other arm, while its further progress will engage and take along the other arm. In the operating mechanism a stop is arranged to occur in case both arms do not reach this position at once. A hydraulic buffer, against which the end of the counterweight arm takes bearing, prevents impact when the draw is closed, and a similar buffer checks the opening movement. For the better concentration of its mass, and to enable the center of gravity to be located most favorably, the counterweight is of lead, which is poured into pockets between cross girders. The lead has the additional advantage of being a durable material, requiring no maintenance expense.

The trunnions rest on support girders which extend back and are built into the masonry to transmit the arch thrust. The pressure on the trunnion bearings for the dead load is 1,100 pounds per square inch, and the maximum pressure from resultant of live and dead loads is 2,440 pounds per square inch. No center latch is required and no rail lifts. There are end wedges, as shown. Continuity of the track rails over the places of opening is obtained by means of interfering ends which give split-rail joints; these joints are entirely on one side of the openings. Spaces are left for the clearance of the ends projecting from the other side during revolution. The hand rails on the draw are 6 inches farther out than on the fixed parts, and revolve past the latter. Operation is by means of electric motors, one for each arm, engaging simple and direct trains of gears, as shown. The motors are of 50 horsepower each, and have 300 revolutions per minute. While the two motors are connected by a submarine cable and can be operated from one point, it will be preferable to have an operator on each side. The draw can be opened or closed in one minute or less. In designing the drawspan the governing considerations have been to combine stability when closed with simplicity of operating machinery and general durability of parts.

The 355-foot arches will be erected on false work; the bascule arms for the drawspans will be erected on end in the position which they will assume when open.

The Arlington approach consists of three groups of five 75-foot arches, separated by 140-foot arches, and an embankment supported by retaining walls on the higher ground. The general character and outline of the masonry are the same as for the Washington approach. The 140-foot openings serve as channels for Little River, which can easily be diverted to them. At station 48 plus 68 a tunnel 28 feet wide and 23 feet high at the crown, passing under the embankment, will afford space for two tracks of the Washington and Southern Railroad and give 21 feet headway over each track. At present this railway has but one track. This track will have to be lowered 12 feet to elevation 26.9′ in order to pass under the structure, which will be facilitated by changing the alignment to the abandoned canal at this point. The Washington, Alexandria and Mount Vernon Electric Railway is lowered 17 feet to elevation 33.5′ and passes under the structure at station 54 plus 84 through a skew tunnel of 20 feet normal width and 15½ feet height at the crown, giving room for two tracks with 14 feet headway over each. This arrangement will enable these tracks to be diverted from the proposed plaza at the end of the bridge. At station 50 plus 55 there is a circular enlargement 200 feet in diameter, from which radiate two branches, one northwestwardly on an up grade of about 1.6 per cent, 310 feet to the Georgetown and Alexandria road forming a driveway to the Ord and Weitzel gate, and the other southwestwardly toward the Sheridan gate, of the National Cemetery, carrying the two trolley tracks down a grade of about 1 per cent 630 feet to a junction with the Washington, Mount Vernon and Alexandria Electric Railway tracks.

At the western end of the structure there is a plaza terminating in a proposed new gate to the national cemetery, from which gate a new driveway toward the Arlington manor and Fort Myer is proposed. The elevation of the plaza is 55 feet, which will require a fill of about 8 feet on the center line. This plaza will be free from street-railway tracks, and the proposed gate at this point will form the principal entrance to the cemetery. The chief decorative feature of the plaza, as suggested, is an equestrian statue of Washington surrounded by statues of other national heroes. This general scheme for entering the cemetery forms an imposing terminal to the bridge without encroaching unduly on the cemetery grounds, provides for the switching and turning aside of the trolley tracks, and serves to make less apparent the fact that the cemetery wall is not at right angles with the bridge.

In general, the decorative scheme has been intended to accentuate the memorial character of the bridge without detracting from its utilitarian and constructive value. The general design can be simplified or elaborated without defeating this aim.

Elevations are taken from 0 at low tide level, and all stations as located by intersections are taken on the axis of the structure. All transverse face walls of piers and abutments and center lines of skew backs are at right angles to this axis.

The piers are numbered consecutively from the east, beginning with No. 1, the Washington abutment, and ending with No. 31, the Arlington abutment, at the west end of the open construction. They are located as follows:

	Stations.
West face of Washington abutment	6+57
Center line of—	
Pier 2	8+17
Pier 3	9+17
Pier 4	10+02
Pier 5	10+87
Pier 6	11+72
Pier 7	12+77
Pier 8	14+13.5
Pier 9	15+47.5
Pier 10	19+55.75
Pier 11	21+44.25
Pier 12	25+52.5
Pier 13	26+86.5
Pier 14	28+23
Pier 15	29+28
Pier 16	30+13
Pier 17	30+98
Pier 18	31+83
Pier 19	32+83
Pier 20	34+63
Pier 21	35+63
Pier 22	36+48
Pier 23	37+33
Pier 24	38+18
Pier 25	39+18
Pier 26	40+98
Pier 27	41+98
Pier 28	42+83
Pier 29	43+68
Pier 30	44+53
East face of Arlington abutment	45+33

As shown on Sheet No. 1 the structure follows the required line defined on print A accompanying your letter of July 21, 1899. This line deflects about 6 degrees and 45 minutes from the center line of New York avenue.

The Washington approach extends from station 0, the intersection of Twenty-third street and New York avenue, to pier 7, near the east bank of the Potomac River.

The bridge proper, from pier 7 to pier 14, at the west high-water shore line of the river.

The Arlington approach, from pier 14 to station 55 plus 48, the east side of the Georgetown and Alexandria road.

The grades are as follows: Beginning with elevation 47′, at station 0, there is an upgrade of 1.94 per cent for 617 feet to 40′ from the first arch, elevation 59′; a level for 785 feet over the viaduct across the Potomac Park to station 14 plus 02, the east face of pier 8; an upgrade of 0.52 per cent for 573 feet to station 19 plus 75 on pier 10, elevation 62′; a level of 150 feet across the drawspan; a down grade of 0.52 per cent for 573 feet to station 26 plus 98, the west face of pier 13, elevation 59′; a down grade of 0.08 per cent to station 45 plus 33, at the east face of pier 31, elevation 57.5′ (this last down grade for the substantially long level of 1,835 feet is intended to correct any optical illusion of hollowness); a down grade of 0.48 per cent for 522 feet to a plaza at station 50 plus 55, elevation 55′; and finally continuing along the center line a level at elevation 55′ to the Georgetown and Alexandria highway.

A width of 20 feet along the center line of the roadway of the 80-foot design is allowed for the two street-railway tracks, which are of standard 4 feet 8½-inch gauge, are flush with the roadway surface, and are spaced 10 feet apart on center lines. The roadway is crowned 5 inches, the berm being outside of the street railway space, which is level. The curbs are 6 inches high and the sidewalks slope 1 inch. The grade elevations are taken on the center line of the roadway. The railway tracks have 9-inch 107-pound rails and 7-inch 67-pound slot rails placed on standard cast-iron yokes in concrete base on the masonry spans and on stringers or girders over the steel spans. The roadway pavement is asphalt on concrete, and the

sidewalks are granolithic, both supported by buckle plates on the steel spans. On the drawspan cinder concrete is used and the surface is English cork brick.

The foundations throughout the structure, except for some parts of the retaining walls at the ends, are carried to the underlying rock. It is proposed to sink all foundations, except those for piers 10 and 11, the mid-river piers, by means of braced cofferdams, the walls of which consist in general of 12-inch by 12-inch timbers, covered with vertical sheathing 3 inches thick, tongued and grooved, all of Southern pine. The cutting-edges of the cofferdams will be steel shod.

Piers 10 and 11 will be sunk by means of pneumatic caissons indicated in cross section on sheet No. 16. The working chambers of these caissons will be 8 feet high with roofs 4 feet thick. The walls will be of 12 by 12 inch timbers with 3-inch vertical sheathing, and will extend upward, forming cofferdams for the caissons.

All foundations, except those for piers 10 and 11, will be of Portland cement concrete to an elevation 2 feet below low water. Above this point the masonry consists of granite face walls with other suitable stone for backing, except in the 10-foot piers between the 75-foot arches, which are of granite throughout up to the springing line, and except in piers 10 and 11.

In piers 10 and 11 the working chambers and interstices will be filled with Portland cement concrete up to 9 feet above the roofs of the working chambers. Above this elevation granite will be used throughout up to the level of the skew backs of the 355-foot arches, above which the face walls only will be of granite and the backing of other suitable stone.

Appended hereto are general specifications showing the quality of materials and workmanship required, and estimates of cost.

In closing I wish to express my deep obligation to my associates for the zeal and efficiency with which they have cooperated in the preparation of my designs, and to say that any merit which the designs may have is due in large part to them.

I am, sir, very respectfully, your obedient servant,

L. L. Buck.

Charles J. Allen,
Lieutenant-Colonel, Corps of Engineers, U. S. A.

GENERAL SPECIFICATIONS.

[To accompany Mr. L. L. Buck's designs for proposed memorial bridge across the Potomac River at Washington.]

The designs are described in the accompanying monograph.

LIVE LOAD.

1. In addition to its dead load, the structure is designed to carry the following live loads:

Two hundred pounds per square foot for a width of 10 feet on each street railway track, or 30,000 pounds on one axle on either track or both tracks; and

One hundred pounds per square foot on the roadways and sidewalks, or a 20-ton road roller anywhere between the curb lines.

UNIT STRESSES.

2. In computing required sections the following unit stresses in pounds per square inch will be used:

	Live load.	Dead load.
Tension, net section	10,000	18,000
Compression: P equals	$\dfrac{10,000}{1 \text{ plus } \dfrac{L^2}{18,000\ R^2}}$	$\dfrac{18,000}{1 \text{ plus } \dfrac{L^2}{18,000\ R^2}}$

Maximum permissible pressure on masonry, 300 pounds per square inch.

QUALITY OF MATERIALS.

3. *Timber.*—The timber of the pneumatic caissons and the cofferdams will be long-leaved yellow pine, free from rot, shakes, cracks, and loose or decayed knots. It will be sawed square and of full dimensions. The timber for the walls and decks will be dressed accurately on all sides to uniform dimensions; all other timber will be dressed on opposite sides to a uniform thickness for each course.

4. *Portland cement.*—The cement for the stone masonry and the concrete will be an approved brand of Portland cement.

Briquettes of neat cement, exposed in air for twenty-four hours and then immersed in water for six days, must have a tensile strength of at least 350 pounds per square inch.

Briquettes mixed of one part of cement to two parts of dry sand by weight, exposed in air for twenty-four hours and then immersed in water for six days, must have a tensile strength of at least 150 pounds per square inch.

Pats of neat cement set in air and then immersed in water shall show no checks nor cracks.

All Portland cement must be fresh and finely ground. At least 90 per cent of it must pass through a sieve of 10,000 meshes per square inch.

The test for tensile strength will not be considered final or conclusive in determining the character of any cement, nor as compelling the acceptance of a cement otherwise objectionable in the opinion of the engineer. Uniformity in quality is desired.

All cement must be carefully handled and protected from the weather and moisture at all times.

5. *Sand.*—All sand for mortar must be clean, sharp, and free from mica. For masonry it must be passed through screens having openings one-eighth of an inch square.

For concrete it must be free from stones and large pebbles.

6. *Concrete.*—Concrete will be made with clean screened, hard, angular, machine-broken limestone, trap rock, or equally good stone of not more than 2 inches in largest dimensions, mixed with smaller stone of the same kind not less than one-quarter of an inch in least dimension, and with mortar in such quantity that when lightly rammed it will flush full all the interstices between the stones. The proportion of stone to mortar in the concrete shall not exceed six parts to three by measure.

The broken stone, washed clean, will be added to the mortar while wet, and the mass will be thoroughly mixed by machine before being put into place. The least amount of water shall be used, as determined by the engineer. The concrete will be deposited in even layers of not more than 12 inches in thickness. It must be well rammed until the mortar flushes to the surface. Each layer must be cleaned and moistened before the next layer is added.

7. *Masonry.*—The stone for the masonry throughout, except where otherwise permitted, will be of granite of the best and strongest quality, equal to the best Maine granite, uniform in texture and color, perfectly sound and free from sap, seams, cracks, or other defects liable, in the opinion of the engineer, to impair its strength, durability, or appearance.

The backing stone, where other than granite is permitted, may be any stone that has a large specific gravity and in the opinion of the engineer possesses great strength and durability. Every stone must be perfectly sound and free from sap, seams, flaws, loose spawls, or any defect liable, in the opinion of the engineer, to impair its strength or durability.

The masonry will be founded upon the solid rock, except where otherwise directed by the engineer. All underlying rock which, in the opinion of the engineer, is unsuitable for foundations shall be removed to such depths as may be necessary.

The surface of the rock shall be leveled off or cut down to such planes as the engineer may direct, and all hollows and fissures will be filled with mortar or concrete as directed.

The masonry will be laid in regular courses, except where otherwise shown on the drawings, not less than 18 inches thick, the thickest courses at the bottom. It must be thoroughly bonded throughout, and no stone in one course shall overlap the stones of the course next below by less than 1 foot. Each stone shall have at least as much bed as rise.

Where required by the engineer, detail drawings showing the plan of each course must be submitted to the engineer before that course is laid.

All cut or molded stones shall be cut truly to conform to the detail drawings, to lay one-fourth inch joints for $1\frac{1}{2}$ inches in from the face and one-half inch joints for full 12 inches back from the face, with sharp, clean arrises.

Face voussoirs of all arches will be cut to close plane beds and joints extending through the stones.

All face stones, except where otherwise shown on the detail drawings, will be fine-axed (six-cut).

Rock-faced face stones will be cut to draft as shown on detail drawings.

Rock-faced masonry must be uniform in appearance and must not project more than 3 inches beyond the pitch lines; it must average at least 1½ inches beyond the pitch lines and have no depression extending back of them.

The upper and lower beds of each stone must be rough pointed and cut true and parallel with each other or radial for voussoir stones; they must be true to straight-edge or template all over and free from wind. No hollow or slack cutting nor falling away toward the back of the stone will be allowed.

No plug holes more than 9 inches in diameter or more than 1½ inches deep or within 1 foot from each other or from the edge of a stone will be allowed.

In all masonry the bottom bed shall always be the full size of the stone, and no stone shall have an overhanging top bed.

Every second or third stone in the face of each course shall be a header. Each header must be at least 2 feet in width, and its length shall be at least three times its height.

Stretchers shall be not less than twice nor more than four times their height in length nor less than 2 feet wide.

The backing stones shall be of the same thickness as the face stones of the same course and their beds shall be cut to the same requirements. Their vertical sides may be roughly squared. The stones shall not touch each other, and the spaces between them shall not average more than 3 inches and must not exceed 5 inches in width at any point. All spaces shall be filled with mortar and spalls and selected pieces of stone driven in until the whole is full. The backing stones shall be of suitable size, roughly rectangular, oblong in shape, of a width not less than their height, and so placed as to bond the work completely and continuously throughout.

All stones must be carefully cleaned and wet before being laid, and stones already laid must be cleaned and moistened to receive the mortar bed for each stone to be laid on them.

All stones shall be laid on their natural beds in full flush beds of mortar mixed fresh as required for the work.

All vertical joints must be thoroughly flushed with mortar, and the vertical joints of the backing must be carefully filled with small stones and spalls flushed with mortar.

No grab holes shall be made in the finished faces of any cut or mouled stones.

The face masonry must be kept clean at all times.

Face joints will be cleaned out to a depth of 1½ inches and pointed in mild weather with mortar made of equal parts by measure of Portland cement and sand, which shall be driven in hard with a calking iron. The surface of the joint will then be rubbed smooth with a rounded tool.

8. *Mortar.*—For all the concrete and the masonry the mortar, except for pointing, will be made of Portland cement in the proportion of 375 pounds of cement to 8½ cubic feet of sand.

The cement and sand will be thoroughly mixed dry. Clean fresh water will then be added, but only in quantity sufficient to give the proper consistency to the mortar when the mixing is completed.

Mortar left over till it has partially set shall not be used on the work.

9. *Steel.*—All steel will be made by acid or basic open-hearth process.

Acid steel.—Acid steel shall be made in an open-hearth furnace lined with silica.

The stock from which acid steel is made shall consist entirely of pig iron or of pig iron and acid open-hearth scrap.

When acid open-hearth scrap is used, it shall not exceed 25 per cent of the furnace charge.

No portion of the stock used shall contain more than 0.10 of 1 per cent of phosphorus nor more than 0.05 of 1 per cent of sulphur.

The use of iron ore for the reduction of carbon in the furnace charge will be permitted according to usual and good practice.

During the reduction of steel in the open-hearth furnace it shall not be decarbonized below 0.10 of 1 per cent.

The recarbonization of steel and the addition of manganese shall be accomplished by the use of ferromanganese or spiegeleisen only, and shall be performed in a careful manner most likely to give uniform results.

Finished acid open-hearth steel shall not contain more than the following proportions of the elements named:

Phosphorus	0.07 of 1 per cent.
Sulphur	.04 of 1 per cent.
Manganese	.50 of 1 per cent.
Silicon	.10 of 1 per cent.
Copper	.02 of 1 per cent.

Test specimens cut from the finished material shall have the following physical properties:

Kind of material.	Strength in pounds per square inch.	Elongation in 8 inches.	Reduction in area.
		Per cent.	Per cent.
Shapes and universal plates	60,000 to 68,000	22	44
Sheared plates	60,000 to 68,000	20	44
Pins and trunnions	68,000 to 76,000	18	40
Rivet rods	54,000 to 60,000	25	50

Specimens cut from plates and shapes shall bend cold 180° around once their thickness, when at or above a red heat 180° flat, and when quenched in water at a temperature of 80° F. 180° around three times their thickness.

Basic steel.—Basic steel shall be made in an acid open-hearth furnace lined with dolomite.

The stock from which basic steel is made shall consist entirely of pig iron or of pig iron and basic open-hearth scrap.

When basic open-hearth scrap is used it shall not exceed 25 per cent of the furnace charge.

No portion of the pig iron used shall contain more than 0.15 of 1 per cent of phosphorus nor more than 0.05 of 1 per cent of sulphur.

No portion of the basic open-hearth scrap used shall contain more than 0.05 of 1 per cent of phosphorus nor more than 0.04 of 1 per cent of sulphur.

The use of iron ore and lime for the reduction of carbon and phosphorus in the furnace charge will be permitted according to usual and good practice.

During the reduction of steel in the basic open-hearth furnace it shall not be decarbonized below 0.10 of 1 per cent. Any excessive additions of pig iron at any time after the melting of the charge and before tapping will be taken as evidence of excessive decarbonization.

The recarbonization of steel and the addition of manganese shall be accomplished by the use of ferro-manganese or spiegeleisen only, and shall be performed in a careful manner most likely to give uniform results. The use of coke or charcoal in recarbonizing the steel will be good cause for rejection.

Test specimens cut from finished basic open-hearth steel shall not contain more than the following proportions of the elements named:

Phosphorus	0.04 of 1 per cent.
Sulphur	.03 of 1 per cent.
Manganese	.30 of 1 per cent.
Silicon	.10 of 1 per cent.
Copper	.02 of 1 per cent.

Specimens cut from finished basic open-hearth steel shall have the following physical properties:

Kind of material.	Stength in pounds per square inch.	Elongation in 8 inches.	Reduction of area.
		Per cent.	Per cent.
Shapes and universal mill plates	52,000 to 60,000	25	50
Sheared plates	52,000 to 60,000	22	50
Pins and trunnions	60,000 to 68,000	20	40
Rivet rods	50,000 to 56,000	25	50

Specimens cut from plates and shapes shall bend when cold 180° flat, when at or above red heat 180° flat, and when quenched from a medium yellow heat in water at a temperature of 70° F. 180° around twice the thickness of the specimen.

Specimens cut from pins shall bend when cold 90° around the thickness of the specimen, and when at or above a red heat 180° flat.

Both acid and basic steel.—The elastic limit shall not be less than one-half the ultimate strength.

The finished steel shall be made into bottom-cast ingots weighing not more than 5,000 pounds each and cast in groups of not more than six ingots to each group.

All bending tests shall show no signs of fracture on the outside of the bent portion.

The fractures of all tension tests shall have a cup or an angular shape and shall show a fine silky texture of a bluish gray or dove color, free from black or brilliant specks.

All rolled or forged material shall be entirely free from piping, checks, cracks, or other imperfections, and shall have smooth finished surfaces and edges.

Rivets cut out of the work when required by the engineer or his representative shall be tough and show a silky texture without crystalline appearance.

Rigid tests will be made for red shortness.

Steel for castings.—Steel for castings shall be made in an open-hearth furnace lined with silica.

At least one-third of all stock used for castings shall be pig iron; and where scrap is used such scrap shall be of a kind and quality satisfactory to the engineer.

During the reduction of the steel in the furnace it shall not be decarbonized below 0.10 of 1 per cent.

In making steel for castings the use of iron ore, ferrosilicon, ferromanganese, and spiegeleisen will be allowed according to usual and good practice.

The finished steel shall not contain to exceed the following limits of the elements named:

Phosphorus	0.06 of 1 per cent.
Sulphur	.04 of 1 per cent.
Manganese	.80 of 1 per cent.
Silicon	.35 of 1 per cent.

All steel castings shall be carefully and thoroughly annealed.

Test pieces taken from coupons on the annealed castings shall show an ultimate strength of not less than 60,000 pounds per square inch, an elongation of not less than 20 per cent in 2 inches, and shall bend 90° around three times their thickness without rupture.

All steel castings must be true to the drawings, with smooth surfaces, and all reentrant angles must be neatly filleted. They must be planed smooth and true where the drawings require, and all holes for bolts must be drilled accurately.

All castings must be as sound and as free from blowholes as the latest and best practice can produce.

General provisions as to steel.—All steel shall be made in works of established reputation for the kind and character of materials specified.

All orders for steel shall have embodied in them the full specified requirements for the same, and manifold copies of all steel orders shall be mailed to the engineer at the time of placing the same.

All stock and materials used in the manufacture of the steel, and all operations at the furnaces or rolls or elsewhere about the establishments where the steel is made or manipulated, shall be subjected to the examination, approval, and acceptance of the engineer or his authorized inspectors, who shall have free access to all records appertaining to its manufacture from the beginning until its final acceptance, and shall upon their request be furnished with neat and legible copies thereof.

All superintendents, foremen, melters, helpers, and others engaged in the manufacture of steel for this work shall be men experienced in their line of work and of sufficiently recent practice to insure the best results.

The manufacturer shall have an analysis of every melt made by a chemist satisfactory to the engineer, and two copies thereof certified by such chemist shall be delivered to the inspector appointed by the engineer or his representative. Check analyses of the finished steel may be made at any time, and shall not show an increase of more than 25 per cent over the specified limits for phosphorus and sulphur.

Every facility shall be afforded to the inspectors to verify the reqirements for every melt of steel.

All specimens for testing must be made to shape required by the inspector, at the expense of the contractor.

The inspection will be very thorough, and tests will be made and repeated as often as is deemed necessary by the engineer in order to satisfy him that none but the best material goes into the work.

Acceptance of any material at the mill, foundry, or elsewhere before its use will not be considered as final. Should any piece prove to be defective, under any of its manipulations before it is in its final position on the work, it will be rejected, and must be replaced by a satisfactory piece, without additional compensation to the contractor.

When open-hearth steel is made in mills producing more than one kind of steel, no material will be accepted unless made especially for this work; and, when so made, it will be subject to a system and method of identification approved by the engineer; and, furthermore, such especially made steel shall be handled and manipulated by itself or isolated in any manner required by the engineer to prevent any possibility of its becoming mixed with other kinds of steel.

No steel shall be made or cast unless the engineer or his representative is present.

Testing steel.—Specimens for testing shall be cut from the actual material made for the work. There shall be a sufficient number of them to satisfy the engineer that the material is what is required.

Specimens from plates, shapes, and pins shall be planed or turned to a rectangular or cylindrical form for a length of not less than 8 inches, and shall have a cross sectional area of not less than one-half a square inch. Specimens from pins shall be taken at a depth equal to one-third the radius of the section. Rivet specimens shall be cut directly from the rods without further preparation.

WORKMANSHIP.

10. *Riveted work.*—All plates and angles to be riveted, which do not exceed three-fourths of an inch in thickness, shall be punched one-fourth of an inch less in diameter than the rivets to be used.

All shapes over three-fourths of an inch thick shall be drilled and not punched.

All plates and angles must have all sheared edges removed by a planer to the depth of at least one-eighth of an inch.

They shall then be coated with raw linseed oil.

The plates and angles will then be straightened, assembled, and reamed to a diameter one-sixteenth of an inch greater than that of the rivets to be used in them.

They will then be taken apart and have the edges of the holes slightly filleted to remove all fins and sharp angles.

Surfaces that are to become inaccessible will then receive a protective coating, to be approved by the engineer, after which they will again be assembled and thoroughly and tightly bolted.

11. *Riveting.*—Wherever practicable all rivets will be machine driven, both in the shop and in the field.

Whenever hand riveting is necessary, the entire driving must be done with sledges weighing at least 8 pounds, and the rivets must be held by dollies capable of holding them firmly against such driving.

All rivets must thoroughly fill the holes, have full hemispherical heads concentric with their bodies, and grip the work tightly.

All work must be kept thoroughly and tightly bolted while the rivets are being driven, and all members must be true and out of wind when completed.

Great care must be taken that all rivets are properly heated, and no overheated rivets will be permitted.

Previous to assembling for riveting all steel must have the mill scale entirely removed by sand blast, thoroughly cleaned with wire brushes, and fully protected from rust by oiling. When it is ready to leave the shop all dirt shall be removed, and it shall be immediately covered with a thorough coating of paint to be approved by the engineer.

12. *Abutting ends, splices and gussets.*—All abutting ends and edges shall be milled or planed so that the parts will fit neatly and tightly together.

All joints must be assembled after milling, and the holes in the splice plates and gussets must then be reamed or drilled, so that they will agree perfectly.

12a. *Trunnions.*—The trunnions will be forged and must be finished smooth and truly cylindrical to the diameters and lengths required on the drawings. They will have holes 2 inches in diameter, concentric with their cylindrical surfaces, bored through from end to end.

13. *Pins.*—All pins must be turned smooth and truly cylindrical to the diameters required by the drawings. They must be of the required lengths.

All pins more than 5 inches in diameter shall be hammered or pressed.

All pins having diameters greater than 6 inches must have holes $1\frac{1}{2}$ inches in diameter, concentric with their cylindrical surfaces, drilled through from end to end.

All pin holes must be bored smooth and true to diameters not exceeding one-fiftieth of an inch larger than those of the pins to be used.

14. *Screw threads.*—All screw threads will be of the United States standard. The threads shall be full and the nuts must fit neatly.

15. *Protective coatings.*—Before shipment all steel work, except bright machined work, shall be thoroughly cleaned and shall receive an additional coating of a paint to be approved by the engineer.

Bright finished work shall be covered with slushing oil to prevent rusting.

16. *Erection.*—All men employed on the work must be skilled in the work of their respective departments. All completed work must be carefully and fully protected from injury while the erection is going on.

17. *Painting.*—After the steel work is erected and completed it will receive two thorough coats of a paint to be approved by the engineer, which will harmonize in color with the remainder of the structure.

18. *Ornamental work.*—Models for all ornamental details will be prepared by special artists under the direction of the architects.

19. *Bronze standards and brackets.*—The metal will be of United States standard bronze, composed of 90 parts of copper, 7 parts of tin, and 3 parts of zinc.

The sculptors' models will be cast in bronze, and these first bronze castings will be highly hand chased in the very best manner and used as master bronze patterns. They must be approved by the architects before castings are made therefrom.

All castings must be sharp and clear, and of proper thickness for castings of the proposed size, averaging not less than three-eighths inch on smaller parts and one-half inch on larger parts.

Castings will be made in French sand and in even-dried molds.

Castings must have no sand or blow holes or similar imperfections; they will be hand chased; all burr, seams, and imperfections must be removed by hand chasing; and no joints, rivetings, bolt or rivet heads will be allowed to show on the finished work.

All work will be finished in oxidized statuary bronze color (brown), and must be executed to the entire satisfaction of the architects.

FINAL.

20. The monumental character of the work renders it imperative that it shall be done only by establishments whose experience, reputation, and plant are such as to insure that all materials and workmanship shall be of the first class, and that the completed structure shall represent the latest and best practice and the highest ideals in engineering, architecture, and art.

Dated, New York, January 29, 1900.

L. L. Buck.

Estimates of cost.

	80-foot design with railway.	60-foot design without railway.
For bridge and approaches finished in six-cut masonry throughout, exclusive of ornamentation and plazas	$6,891,230	$5,192,400
For all projecting and ornamental work, namely, pier buttresses, shields, buttress piers, pedestals, monuments, towers, balustrades and coping for same, together with cornices, brackets, bronze lamps and railings, iron railings, etc., but not including statuary or figures	7,568,000	7,568,000
For Washington plaza	400,000	400,000
For Arlington plaza and entrance to cemetery	1,520,000	1,520,000
For changing and lowering railroad tracks	55,000	55,000
Total	16,434,230	14,735,400
For all of the foregoing work, but with bridge and approaches finished in rock-face masonry	15,409,000	13,940,000

Dated New York, January 29, 1900.

L. L. Buck.

MEMOIR SUBMITTED WITH THE DESIGNS OF MR. WILLIAM H. BURR.

NEW YORK CITY, *January 15, 1900.*

DEAR SIR: In response to your invitation of July 21, 1899, and in accordance with the subsequent communications from you, I submit herewith designs for the memorial bridge across the Potomac River from Twenty-third street and New York avenue, in Washington, to the Georgetown and Alexandria road on the Arlington estate.

These alternative designs, made under the terms of your invitation above mentioned and your subsequent letter of November 6, 1899, are all located along the line called "trial survey line No. 1," shown on blue print "A," transmitted to me with your invitation to make designs for the memorial structure.

In making these designs it has been the endeavor to fulfill in the most effective manner the requirements of strength, grace, durability, and economy. It is obviously necessary first to meet the requirements of the best engineering practice in that part of the designs which belongs peculiarly to engineering, but at the same time to characterize the engineering design with such lines and proportions and with such architectural embellishments as may best serve the purposes of a memorial structure dedicated to American patriotism. These conditions require a type of structure possessing graceful outlines and proportions which shall provide in the most reasonable manner for the traffic across the bridge and the water traffic along the Potomac River. Some adaptation of the most graceful of bridge structures, the arch, is obviously required to meet the exacting conditions of this case, and the designs which accompany this memoir have the arch as the distinguishing structural feature.

In order to meet the requirements of navigation it was necessary that some form of movable bridge should be constructed over such portion of the navigable channel as your data indicated as most advisable. The common form of movable structure, the draw or swing bridge, consisting of two arms or trusses revolving about the vertical axis, does not offer a sufficiently graceful appearance to meet the requirements of this case, nor does it permit desirable architectural treatment of the adjacent features of the structure. Lift bridges have been both designed and constructed, but in consequence of uncertainties of operation, which have been experienced in a number of cases, and of their unsightly appearance it has seemed that the bascule type should be selected as the proper movable feature for this structure. When the two leaves of the bascule are lifted a clear opening of indefinite height is provided, contributing both to the capacity of the opening and to the monumental character of the adjacent features of the bridge. The two bascule piers thus afford facility of treatment for monumental towers, which at the same time contribute essentially to the stability of the piers on which they stand, those piers being abutment piers for the adjacent arches. There is thus a unity in motive of design and construction in this portion of the bridge, which affords opportunity for the chief monumental features at the center of the river, where they may be most imposing and effective.

This location of the bascule at the same time divides the river portion of the structure into suitable spans for economic and impressive construction.

Your invitation of July 21 requests two designs, one of which, with river spans of steel, shall provide for a roadway and two sidewalks on the upper deck of the structure and for two electric trolley cars below the upper deck, at a suitable height for the accommodation of the electric-car traffic; the other being a design in which provision for the two electric-car tracks are omitted, and which should be, in accordance with the language of your invitation, "a single-deck memorial highway bridge."

Designs Nos. 1 and 2, transmitted herewith, are intended to meet the requirements of your original request.

Your letter of November 6, modifying the requirements of the original specifications, stated "That in addition to or as substitute for plans for a bridge in exact accord with the specifications of July 21, the designers will be permitted to submit plans contemplating the use of such material for the piers and superstructure as may appear to them most proper and appropriate, provided the piers and abutments are of durable stone masonry and suitable to the character of the structure."

At the time of the receipt of this letter designs Nos. 1 and 2 were in a forward state of progress, and instead of substituting a design for either one of those I concluded to take advantage of the permission given in your letter of November 6 and submit an alternative plan in addition to the two originally asked for, and plan No. 3 is such a design. Explanatory matter applicable to each one of the three designs in turn will be given farther on.

A careful study of the blue-print plans submitted with your original request, supplemented by a thorough examination of the location on both sides of the Potomac River, indicated that the crown of the roadway on the Arlington approach and on the river spans could be made level at the elevation of 65 feet above mean low water

This elevation gives at least 50 feet clear under the center of the various river arch spans in designs 1 and 2, with a minimum clearance of 24 feet above mean low water at the springing joints. The embankment part of the Washington approach, however, starting from Twenty-third street and New York avenue, rises with an easy grade of 2 per cent until the elevation of 65 feet is reached. These observations as to the elevation of the crown of roadway and the clearance under the arches, as well as the grade on the Washington approach, apply only to designs Nos. 1 and 2.

It will be shown in discussing design No. 3 that the elevation of 91 feet above mean low water for the crown of the roadway, giving a clear height of 74 feet under the center of the river arches, is necessary in that case.

In the execution of these three designs one of the chief aims has been to use such material as best harmonizes with the memorial character of the structure under the terms of your specifications, which made granite masonry the feature of all masonry portions of the design. That material is consequently used for both approaches and the river spans except in that design in which a steel superstructure is permitted for the river spans or the bridge proper. The best engineering practice during the past few years has developed a special adaptation of combined concrete and steel, which possesses in the highest degree strength, durability, and economy, and that combination has been used for the backing, so to speak, of the granite masonry in all three designs where masonry arches are employed. The steel used is a small percentage in section of the total sectional area of the concrete and is entirely embedded in the latter, with no part nearer than 2 inches to the surface. These conditions insure the indefinite preservation of the steel. The surface of the sheeting would be smoothly finished with a thickness of not less than 2 inches of rich Portland-cement mortar of one cement to two of selected sand, thus securing an enduring monolithic surface.

The approach arches in both designs Nos. 1 and 2 and the river spans of design No. 3 are all made with granite masonry arches, backed with sheeting of combined concrete and steel. The combined concrete and steel has been arranged in all cases in five ribs with coffers between, so disposed as to insure the most effective and economical disposition of material and to exhibit a continuous sheeting under the arches. By these means a granite masonry structure is secured, with the advantage of a sheeting possessing the greatest capacity of resistance which can be given to masonry, with indefinite durability, and with the greatest degree of economy which can be attained in masonry construction. It is believed that this type of granite masonry structure is peculiarly adapted to the requirements of the present case. It reduces the dead weight of the masonry structure to a minimum and renders the arches capable of sustaining the highest degree of compression to which any masonry can be subjected, and at the same time gives it, if desired, considerable capacity to resist tension, although that capacity is required to be exerted to no extent whatever in design No. 3 and to a very slight extent only in some small portions of designs Nos. 1 and 2. Very careful consideration has been given to this portion of all three designs, and no feature of any design has been employed which has not been justified repeatedly by extended experience in construction both in this country and Europe. I shall be pleased to give precedents in this field of construction if it should be desired.

This feature of the combination of concrete with steel trusses embedded in it has also been used in these designs for the tops of all the river piers, including the two on the shore, of design No. 2 and in the bascule piers of design No. 1. Those piers in design No. 2 are, for economy, formed with longitudinal arches through them, as is fully shown in the plans. While there is sufficient masonry above those arches to take the thrust of the adjoining arch spans, it was deemed best to secure such additional resistance in the masonry piers as would be given by the presence of the steel trusses or girders, and hence they have been introduced. They give great tenacity to the pier as a whole and render its character even more resisting than if simply monolithic. Such construction renders cracking from any cause whatever practically impossible and adds to the continuity and unity of the pier construction. As the plans show, this resource of strength and stability has been employed wherever possible, although in no case do stress computations show that it is necessary. In other words, it is an element which safeguards the masonry structure, in addition to such margin of safety as stress computations alone may exhibit. The writer has been led to this feature of masonry construction from his own experience in the construction of masonry arches.

Two classes only of concrete are designed to be used in the entire structure of any of the three designs:

Concrete No. 1: Cement, 1; sand, 2; broken stone, 4.

Concrete No 2: Cement, 1; sand, 2; screened gravel, 3; broken stone, 6.

Portland cement only is designed to be used in the entire structure. Broken stone should be good trap or limestone, or other stone of equally good quality, broken so

as to pass through a 2-inch ring and to be held on a 1-inch screen. The screened gravel must be of a satisfactory character, with a sharp gritty surface, all of which must pass through a one-half inch mesh and be held on a one-eighth inch mesh. With this material the mortar prescribed for concrete No. 2 will somewhat more than fill the voids of the mixture of broken stone and screened gravel. The No. 1 concrete is designed to be used wholly in the concrete sheeting and in those portions of the piers and abutments back of the springing joints, and also in the working chambers of the pneumatic caissons. It will also be used for the outer 2 feet around all piers and abutments. No. 2 concrete will be used in all other portions of the structures of all three designs were concrete is employed.

It has been the intention, in prescribing these two grades of concrete, to establish a rich and strong mortar, and then attain voids in such proportion that the mortar will more than fill them. It is believed that in this manner the strongest possible concrete will be produced. The maximum pressure in the combined concrete and steel of the ribs of the sheeting in no case reaches 450 pounds per square inch, and that maximum exists only in the outer skin, so to speak, of the rib. It decreases as the skin of the rib is departed from. This pressure exists only in concrete No. 1. The greatest pressure in the granite river arches of designs No. 2 and 3 is 38 tons per square foot, and that is due to dead load only. The corresponding pressures in the granite approach arches is much less. It is intended that the factor of safety in the masonry of all three designs shall never be less than 10; and it runs from that value to those two and three times as great. The maximum pressure in the No. 2 concrete of the piers is less than 15 tons tons per square foot. As a matter of fact it is believed that the ultimate compressive resistance of concrete No. 2 can not be much less than that of concrete No. 1, but the greatest intensities of pressures are limited as above described.

Two methods are contemplated for the sinking of the foundations, both for the approach arches and those in the river. A careful examination of the blue-print profile transmitted with your original request for plans, together with an examination of the site and practical experience with the sinking of foundations in what appear to be very similar conditions, leads me to believe confidently that all the foundations of the piers in both approaches may be successfully and economically sunk within heavy sheet-piled inclosures; or with a cofferdam constructed with two lines of sheeting around each pier site, suitably separated and filled to a proper height above mean-low water. The greatest depth of material over the rock shown on the blue-print profile is but 35 foot below mean low water, which is well within depths reached by the sheet-piled inclosure method under conditions practically identical with those here considered.

This method may be economically and expeditiously employed with a reasonable amount of pumping only, so as to lay the entire foundation concrete dry in each case, thus producing the best possible results. For the same reasons the abutments or abutment piers at the north and south shores of the river may be sunk in the same way, and the estimates of cost are made accordingly. It is contemplated that the remaining piers, located in the river, shall be constructed by the pneumatic process on steel pneumatic caissons. If it should be found necessary to sink the abutment piers at the two shore lines of the river on pneumatic caissons, the additional cost would not be material, as the total depth of sinking below mean low water is only 35 feet.

In all three designs, the entire roadway surface, with the exception of those portions on the bascules, is composed of sheet asphalt pavement, as you prescribe, while the corresponding portions of the sidewalks are granolithic pavement. The roadway pavement on the bascules must obviously be of such character as to hold its place firmly when in practically vertical position.

There are two types of pavement at least which may be successfully employed for this purpose, which are shown in section on the plans. One such pavement is that composed of asphalt-cork blocks, such as are laid on each side of Fifth avenue near Thirty-fourth street in New York City. These blocks may be molded of any shape and size and with iron bolt anchors, enabling them to be bolted to the buckle plate of the structure. The other type is the wooden-block pavement, which has been much employed for street service, and which is successfully used on the bascules of London bridge. In this type, planks creosoted or otherwise treated, are bolted to the buckle-plate floors, and to them are secured with wooden pins the wooden blocks of the pavement. Either type will make a thoroughly satisfactory floor for the bascules, but the asphalt-cork blocks are a little lighter than the wooden pavement.

As shown on the plans, the floor on the entire structure, including both arch approaches is founded either on buckle plates riveted or bolted to rolled beams over steel spans or on concrete floor arches over masonry spans. This buckle plate and rolled beam or concrete floor for both roadway and sidewalks is carried down to

either the steel arch ribs or to the granite masonry arches with combined concrete and steel sheeting by means of rolled steel I-beam or channel columns in the cases of designs Nos. 1 and 2, and steel latticed channel columns in design No. 3, all as exhibited on the plans. All these steel columns with their longitudinal and transverse bracing, together with the rolled beams above them and the lower side of the buckle plates, are open to the freest inspection and painting. They lighten the structure and form the most economical method of supporting the floor.

The coffers between the combined concrete and steel ribs of the sheeting are fitted with drainage openings at each pier, which discharge below low water, although it is not probable that enough water to require drainage will ever enter them.

If it is desired, limestone or other masonry facing of equal quality may be substituted for the No. 1 concrete for those portions of the piers and abutments which are below low water without any material increase of cost. It is believed that the No. 1 concrete would be equally durable with the limestone or other foundation stone of equal quality.

The bascules of designs Nos. 1 and 3 are identical in character and details except that the bascule trusses of design No. 3 are 17 feet in depth over all, while those for design No. 1 are 15 feet over all. For this reason, and for the further reason that the limited time available practically forbids making it, no separate bascule plan for design No. 3 is submitted. As shown on the plans, the bascule for design No. 2 is shorter than for designs Nos. 1 and 3, but it is of the same general type. These bascules are hung upon a large hollow steel shaft or trunnion with suitable counterweights so that in opening their centers of gravity remain unchanged in elevation. Inasmuch as the inboard ends of designs Nos. 1 and 3 must have provision for the two electric car lines, they are made of plate girders within which suitable accommodation is provided for the counterweights. These plate girder ends, with their counterweights and electrical actuating machinery, are obviously always hidden in the body of the pier.

The actuating machinery of the bascules in designs Nos. 1 and 3 consists of four 50-horsepower electric motors for each bascule leaf, arranged to rotate a pinion engaging with a heavy quadrant steel rack or gear, all as clearly shown on the plans. When a single bascule leaf is rotated or lifted in quiet air, the power required is less than 30 horsepower, but if it should be desired to rotate the leaf during a high wind, nearly the full power of the four motors might be required. Any one of the four motors may be depended upon, consequently, to operate each bascule leaf except against a wind of considerable force. If any one or two or three of the motors, therefore, should be disabled, or if even only one should remain operative out of eight for the entire bascule, vessels could still pass, because the remaining motor would be of sufficient power to operate one bascule leaf under ordinary conditions, and so afford a sufficient opening for one vessel.

The locking machinery at the outboard ends of the bascule is operated by two small electric motors, also as shown on the plans. The locking device must carry some live load shear, and hence it is of great strength. All live or moving load on the bascule acts as loading on an overhanging cantilever, and is balanced or held by an anchorage against which the inboard end of each bascule leaf rests when closed. This anchorage consists, as shown on the plans, of heavy steel members reaching down into the interior of the masonry mass of the bascule pier. While the locking device is capable of transmitting shear, it may not often be required to do so, as each outboard leaf acts as a cantilever for the live or moving load on it. This plan of bascule, with its small amount and simple character of machinery, has little or no liability to derangement, and would be expeditious and effective in opening for or closing after passing vessels. For many vessels, indeed, it would be necessary to lift but one leaf only or both partially. It has many advantages for such a case as this, and lends itself easily to the architectural features of the structure. The bascule feature of design No. 2 is precisely the same as for designs Nos. 1 and 3, except that the leaves are a few feet shorter, and the four actuating motors are each of 35 horsepower instead of 50. The plans for the bascule for design No. 2 are so complete that further general reference is unnecessary.

Provision is made for two lines of electric-car service in designs Nos. 1 and 3 on a lower deck at such elevations as give just enough overhead clearance for the passage of heavy electric cars. It will be observed that in each plan there are five ribs, and that the five ribs are either steel or of combined concrete and steel, and that the two openings between the center rib and the adjacent one on each side are adapted to the passage of electric cars. The requisite transverse bracing for the steel columns above the arches is introduced either below the electric-railroad track or in the outer spaces between the outer pairs of ribs. At either end of the structure adjacent to the embankment filling the electric tracks are led out by easy curves so as to pass on a

berme on either side of the embankment filling. They may then be brought up to the grade of the roadway, or they may be led off in any direction which the interests of the traffic require. By these means the street-car traffic at both ends of the structure may be accommodated with the greatest convenience to the traffic itself or to the use of the main avenues leading to the bridge at either end.

The designs of the piers are such that stairways at those points may readily conduct passengers from the sidewalk surface down to the electric tracks or to Potomac Park at as many points as may be desirable on the structure. In other words, foot passengers may pass down to the electric tracks, or from electric tracks up to the sidewalks of the bridge with the greatest facility at as many points as may be desired. This arrangement affords every desired facility for interchange of traffic between the upper deck of the bridge and the electric railroad deck below.

I have not taken advantage of the privilege offered in your letter of November 6 to place the electric-railroad track at some other elevation than that of a deck below the roadway surface, for the reason that it has seemed to me very undesirable to place electric or other street service tracks on the upper deck of this bridge. That deck will afford one of the most beautiful and attractive avenues for pleasure driving that can be found in the vicinity of Washington, or indeed anywhere in the country, and it should be preserved to the uses of such traffic without the obstruction of constant passage of a street-car service. The latter service can be admirably provided for on the lower deck, and it should be placed there. Its presence on the upper deck would be a serious blemish to the scenic effect and memorial character of the structure.

In accordance with the terms of your request design No. 2 contains no provision for electric-car service.

. The matter of temperature stresses in all these designs has received most careful consideration. The stresses, arising from variation of temperature in a steel-arched rib, may easily exercise a material influence on its stress condition. At the same time, the roadway floor and sidewalks protect even the outer rib largely from the direct influence of the sun, and reduce correspondingly the assumed temperature variations. It is practically impossible, therefore, that the temperature stresses provided for in the steel ribs, should ever exist. The masses of masonry involved in the masonry arches reduce the possible temperature variations very much below those which may be considered possible in the steel arches. Indeed, it is doubtful, whether at the location of this Memorial Bridge so much variation throughout the mass of a masonry arch as 20° F. from a mean temperature would ever occur.

In view of the low modulus of elasticity of masonry, probably not more than one twenty-fifth or one-thirtieth of that for steel, the stresses produced in masonry for such small ranges of temperature would relatively be very small and likely to produce no apparent effect. Further than this, the combined concrete and steel sheeting possesses so great tenacity in consequence of the presence of the steel that no apprehension need be had as to temperature effects. Although such small temperature effects as may arise may readily be computed, they have, for the reasons given, been ignored. In this connection it should be remembered that the rate of thermal expansion and contraction for masonry and iron and steel are practically identical.

The erection of the steel arched ribs of design No. 1 is a simple matter of erection of ordinary steel bridge work. It will only be necessary to put the steel work of each pair of spans in place simultaneously. It would be well, although not strictly necessary, at the same time to have the adjoining masonry arch adjacent to each shore in place on its centers.

The erection or construction of the granite masonry arches with combined concrete and steel sheeting in all the designs presents no special difficulty. This part of the work of the different designs has, however, received the most careful consideration and can be outlined in detail if it is desired. No plans of erection are submitted, as none are called for, but they can readily be developed if required. It will be necessary to erect the river arches in either design No. 2 or in design No. 3 on one side of the bascule opening simultaneously, each bascule pier being a sufficient abutment to take the thrust of the adjoining arch. It will also be necessary in these cases to have one adjoining masonry approach arch constructed on the centering in place to supplement the presence of what may be called the abutment pier at each shore. It would either be necessary to erect all the approach spans simultaneously or in sections of any desired number, one span being in place at each end of each section on its centering to act as an abutment, if necessary, for the thrust of the arches between.

The centering for any masonry arch should be held in place for a period of probably three months after the masonry of that arch is completed. The progress of the

work could be so timed as to accomplish these ends without difficulty or delay in the final completion. With proper plant, organization, and management, the erection work could be completed within a period not exceeding two years.

The cost of erection of all the designs has been very carefully estimated and is included in the estimated cost of the superstructures in all cases.

The plans for all three designs have been elaborated with great care and with detailed analysis. They are suitable, as they stand, for contract drawings. At the same time the ordinary revision given to such plans in an engineer's office prior to the actual execution of the work would result in material economies and possibly in some changes of detail, but without changing in any manner whatever the essential features of the designs.

In the estimates of costs of the various designs no specified percentages or items are shown for engineering or for contingencies, but such items have been included in the cost of all the various grades of work as given in the various estimates which follow.

In the designs for this structure simplicity of form and motive have been the objects sought through the adoption of the arch as the most graceful and monumental form of span. The bascule towers and monuments upon the abutment piers have been added to afford stability, as well as monumental dignity to the structure at the points most suitable for the expression of those qualities.

In design No. 1 the graceful simplicity of the segment has been displayed in the steel river spans, and their impressiveness accentuated by the totally different treatment of the masonry approaches, consisting of a series of semicircular arches, a form of which the eye never tires. The bascule towers, as well as the monumental groups of columns upon the abutment piers, are decorated with groups of sculpture and other ornaments in stone emblematic of the purpose of the structure. The statues occurring along the balustrade of the approaches are designed to represent prominent patriots, and would preferably be of bronze. The electric lamp-posts, placed at frequent intervals, should be of the same material. The bascule towers are crowned by winged victories, and the groups of columns by eagles, all of bronze.

Bronze rails are placed between the stone posts of the approaches, while the whole rail over the steel arches and bascules should be of the same material. All cornices, ornaments, etc., below grade are to be of steel.

In design No. 2 the river arches are of the same simple segmental form, but, being of stone, are of shorter spans. This allows of 3 arches each side of the bascule towers, a number always pleasing to the eye. These are relieved, as in design No. 1, by a totally different treatment of the approaches in a series of semicircular arches, one part setting off the other, thus fully expressing their difference of function.

The bascule towers are crowned by quadregas driven by victories, all of bronze. The other sculptures and ornaments of these towers, as well as of the monuments of the abutment piers, are all supposed to be emblematic in character, and, with the exception of the bronze eagles crowning the latter, would be of the same stone as that forming the structure to which they are attached. The statues of men of renown placed along the stone balustrade facing the roadway, as well as the lamp-posts, would be of bronze.

In design No. 3 the ellipse, graceful of form as well as much more nearly approaching the true lines of stability for arches of this character, is adopted as the controlling motive. The ellipses are all similar and thus contribute to a unity of design which, perhaps, enhances its dignity more than distinct emphasis of the difference in function between the bridge proper and its approaches.

The design possesses the advantage of having only one intermediate river pier on each side of the bascule, and the additional height required to be given to these spans in masonry adds greatly to the impressiveness of the whole structure. The sculptures and other ornaments of the bascule towers and abutment pier monuments are similar in character and material to those of the other designs. As in design No. 2, the whole balustrade, excepting upon the bascules, is of stone, with elaborate bronze lamp-posts placed at the proper intervals.

In all these designs the river portion of the structures, or bridge proper, presents an absolutely symmetrical appearance. The approaches possess apparently the same quality, as the difference in number of a long series of arches does not impress the eye. This characteristic of symmetry is deemed absolutely essential in a monumental structure of this kind.

The bascule towers at the center of the bridge not only afford an opportunity for an exceedingly dignified monumental feature, but also fittingly mark the gateway through which commerce may pass, thus converting a necessity into a most impressive and dignified feature of the whole composition.

DESIGN NO. 1.

The main feature of this design consists of the bridge proper between the Washington shore of the river and that formed by Analostan Island, composed of four steel arched rib spans and one bascule opening, each 303 feet between centers of piers. The arched ribs afford clear spans of 283 feet each at springing lines, and the bascule a clear opening of 213 feet at mean low water. There are 15 full centered granite arches with combined steel and concrete sheeting, each 46 feet in the clear, with piers 7 feet thick at springing line, in the Washington approach. In the Arlington approach there are 21 similar granite masonry arches 46 feet in the clear, each with the same 7-foot thick piers found in the Washington approach. The total length of the river portion of the structure—i. e., of the bridge proper—is therefore 1,515 feet between centers of piers, and the total length of the bridge proper with the two granite masonry arch approaches is 3,437 feet between faces of abutments.

The grade of the centre line of the roadway surface on the river spans the entire Arlington approach, and the granite masonry portion of the Washington approach is level at the elevation of plus 65, but there is an ascending grade of 2 per cent over the embankment from the Washington end of the Washington approach. The face of the Washington abutment is at station 4.96 on the trial survey line No. 1, making 496 feet of embankment fill and abutment masonry on which there is a rising grade of 2 per cent from the intersection of Twenty-third street and New York avenue. The face of the Arlington abutment is at station 40.73, making an embankment fill and abutment masonry of 1,475 feet, about 400 feet of which will be on the Little River flats. The Arlington abutment was located as indicated above with a view to economy, at the same time giving somewhat more clear opening for Little River than is afforded a very short distance farther upstream. If it should be desired, the masonry arch portion of the Arlington approach can be extended southerly to the higher ground of the Arlington estate.

Each arch span of the river portion of the structure is composed of 5 parallel steel-plate girder segmental circular arched ribs, abundantly provided with transverse and lateral bracing. The rise of the center of each rib is 24 feet $7\frac{1}{2}$ inches above the elevation of the center of the pin, the latter elevation being 30 feet $4\frac{1}{4}$ inches above mean low water. Hence the clearance above mean low water at the center of the 283-foot clear spans is 50 feet. Provision is made for the electric street-railway traffic on the lower deck on either side of the center rib. The ribs and all the details of their construction, as well as the bracing and the steel parts of the floor above, have been most carefully designed not only for the prescribed moving loads for the upper deck and trolley lines, but also for wind and for temperature changes, the latter with a total variation of 100° F., or 50° either way from the mean temperature of closure.

There are five parallel steel trusses for the bascule with outboard and inboard arms corresponding to the five steel ribs of the adjoining arch spans, so arranged as to provide for both upper deck and electric car traffic. In consequence of this latter provision it is not possible to make the shaft or trunnion of the bascule continuous from one side of the bascule structure to the other. Hence the weight of the center truss and its loads is carried by three heavy plate girders to the outside trusses. This is accomplished in the manner shown on the plans in a most efficient and satisfactory way. The inboard ends of the trusses, which are always concealed, are advantageously designed as plate girders in order that provision may be most conveniently made for the reception of the necessary counterweights. The rotation of the bascule makes necessary a curved recess in the masonry mass of the upper portion of the pier. The plans show this cylindrical recess with the quadrant steel racks or gears into which mesh the steel pinions of the electric actuating motors.

There is provided at the inboard extremities of the trusses or girders heavy adjustable stops against which those inboard ends rest when the bascule is closed and ready to receive moving load, the fixed or dead load being completely balanced by the counterweights. These stops are heavily anchored to the masonry masses of the bascule piers by the steel members shown in the plans. The adjustable feature of the stops enables the exact elevation of the bascule ends to be reached and maintained. The shafts or trunnions of the bascule are supported on heavy steel frames resting on the granite masonry below them. The pressure between the steel and the masonry is about 250 pounds per square inch. The general character of the locking details at the outboard end of the bascule trusses is specially heavy and effective for its work. Inasmuch as all moving loads on either bascule arm are carried by the latter as a cantilever, the locking device may not be called upon to transfer much moving load shear, as has already been indicated in the general part of this memoir.

The 46-foot clear span granite-masonry arches with combined concrete and steel sheetings are all identical in both approaches. The granite masonry in these

approach arches, as well as in the piers of the river spans, appears either above mean low water or above the surface of the ground. The sheeting is arranged in five ribs with coffers between them in such a way as to secure the highest degree of compressive resistance and tenacity of the masonry and at the same time the greatest possible economy.

As shown by the plans and as already stated the roadway and sidewalk pavements are laid over steel buckle-plates resting on rolled beams supported on rolled steel struts thoroughly braced longitudinally and transversely. These struts or columns distribute the dead and live loads above them on the sheeting and the steel ribs.

The open character of the spandrels of the granite-masonry approach arches give abundant light and air to the electric car deck so as to make the passage through the structure in the electric cars thoroughly agreeable.

At the river piers in this design and at the abutments, as well as at other points in the approaches, means are readily available for the passage of foot traffic from the upper deck to the trolley tracks, or from the latter to the former.

Both abutments are so designed and arranged as to make a graceful finish for the ends of the embankments and to secure the requisite stability of the masonry. The trolley tracks are shown in design No. 3 as being led from the approach arches to either side of the embankment. It is thought that this arrangement may best serve the purposes of the two classes of traffic for which this plan makes provision. If it should be desired, the two trolley tracks can be continued in their alignment through the masonry of the abutment and be brought to the grade of the roadway surface in the center of the latter. In this case the top of the embankment would have to be made sufficiently wide to accommondate the two trolley tracks with a roadway and sidewalk on each side, the latter diverging sufficiently for that purpose. The difference in the cost of the two methods is not material, although the cost of the latter is greater than that of the former.

The steel arch ribs adjacent to the bascule pier exert their thrust not only against the masonry mass of those piers, but also against heavy steel girders embedded in them. There are two such girders in each pier, having what may be termed their upper chords located near the abutting plates of the ribs and diverging to a considerable extent from each other in the mass of the piers. By this arrangement the concentrated thrusts of the ribs are distributed throughout the length of the piers in the most direct and efficient manner. Further, these girders, by distributing the inclined thrust of the ribs into the ends of the pier over which rest the memorial towers, enable the weight of the latter to act much more efficiently than would otherwise be the case in giving stability to the piers against the thrust of the ribs. In other words, they transfer the latter to a sufficient extent to the ends of the piers under the towers.

The two bascule piers and the adjacent piers between the 303-foot spans are designed to be founded on pneumatic caissons built of steel, but inasmuch as the mud and sand at the sites of all the other piers and abutments are found practically at the elevation of mean low water, the foundations are designed to be constructed within heavy sheet-piled inclosures, doubled, if necessary, with suitable filling between to form cofferdams. Those portions of all piers and abutments which are found below mean low water, or below the surface of the ground, will be formed of concrete in the manner already described, or with facing of some suitable stone cheaper than granite, if desired.

It will be observed that the foundations of the shore piers of the river spans, and of all the piers of the approaches and of the abutments, are pierced with arches whose axes are parallel to the axis of the structure. These arches have spans of either 24 or 28 feet, and their springing lines are at the elevation of mean low water. Their crowns are at an elevation of plus 14.

Below the level of mean low water, therefore, the foundations of the piers and abutments named are divided into two parts. This is for the purpose of securing the greatest economy practicable by the most advantageous disposition of the material. This feature will also to some extent facilitate the work of construction of the foundations.

The plans submitted for this design show all the general and detail features of design, the data used in computations, the greatest resulting stresses, the character of the materials used, and all other information requisite for a complete understanding of all features of the design.

The list of plans submitted is as follows:

Sheet 1.—General elevation and plan.

Sheet 2.—Perspective view of structure.

Sheet 3.—Elevation of river span and adjacent approach span.

Sheet 4.—Transverse sections, showing intermediate piers, abutment or shore piers, and approach piers.

Sheet 5.—Transverse section, showing elevation of bascule tower.
Sheet 6.—Side elevation of bascule tower, longitudinal sections, and plans.
Sheet 7.—Plan, elevation, and section of 283-foot clear, steel-arched ribs, with intermediate pier and shore abutment.
Sheet 8.—Plan, elevation, and section of one 46-foot approach span, with one intermediate pier and approach abutment.
Sheet 9.—Plan, elevation, and section of bascule.
Sheet 10.—Stress and section sheet of 283-foot clear span arch.
Sheet 11.—Stress and section sheet of 46-foot clear span concrete steel sheeting.
Sheet 12.—Stress and section sheet of bascule span.
Sheet 13.—Drawings of bascule pier and diagrams of all piers.

DESIGN NO. 2.

In accordance with the terms of your invitation to prepare plans there is no provision made in this design for the two electric-car tracks, either on the main deck of the bridge or on the lower deck. The design is for a "memorial bridge" adapted to street traffic of all kinds, except that which requires tracks.

The river portion of the structure, or the bridge proper, consists of six granite masonry arch spans with combined concrete and steel sheeting, 208 feet from center to center of piers, or 192 feet each in the clear at the springing joints, and one bascule span 266 feet from center to center of piers, or 159 feet in clear at mean low water. The rise of the crown of these arches is 29 feet above the springing joints and the elevation of the latter above mean low water is 24 feet, giving a clearance of 53 feet at the center of the span above mean low water. That portion of the Washington approach adjacent to the river is composed of twelve 60 feet in the clear full-centered granite masonry arches with combined concrete and steel sheeting and with piers 9 feet thick at the springing joints. That portion of the Arlington approach adjacent to the river is composed of eighteen (see appended letter) 60-foot in the clear full-centered granite masonry arches, identical in character and dimensions with those in the Washington approach.

The face of the Washington abutment is at station 5.72 and that of the Arlington abutment at station 41.87, thus making the total length of structure between those stations 3,615 feet. The length of embankment approach and abutment at the Washington end from station 0 is 572 feet, while on the Arlington end there is a length of 1,361 feet of embankment approach and abutment from the end of the granite masonry arches to the east side of the Georgetown and Alexandria road.

The grade of the center line of the roadway surface in this design, over the embankment part of the Arlington approach and all the granite masonry arches of the two approaches as well as of the river spans, is level and at the elevation of plus 65, with a grade of 2 per cent on the embankment part of the Washington approach, precisely as in design No. 1.

The three 192-foot clear river spans on either side of the bascule are segmental circular arches of granite masonry backed with combined concrete and steel sheeting. The latter is formed in five ribs with coffers between, so as to secure the most effective and economical disposition of the material. The curve of these arches is such as to produce a little bending tension in the material of the sheeting, and the steel parts of the ribs are carefully located by computation so as to take that tension and so relieve the concrete of nearly all duty of that kind, the tension in the outer skin of the concrete being in the worst case under 60 pounds per square inch at one point only, and decreasing rapidly as the surface of the sheeting is departed from. There is no steel in these ribs within 2 inches of the surface of the sheeting it being embedded in the concrete nowhere to a less depth than that amount, as shown on the plans. As also shown by the plans, the thin sheeting of the coffers is thoroughly bound together in a tenacious whole by suitable steel members embedded in it, although it carries no load other than its own weight. The plans show in full detail the manner of interlocking the granite masonry with the concrete steel sheeting. No steel anchors between these two portions of the work are shown because they are believed to be unnecessary, but they could be readily introduced should it be deemed desirable.

The general features of the bascule of this design, as to its general form, the number and depth of its trusses, the motive power required for its operation, the heavy stops at its inboard ends, and the locking apparatus at the outboard ends, are all identical with those of design No. 1, and the description of them need not be repeated here. The length of the outboard arms is less than in the bascule of design No. 1 by an amount corresponding to the decreased clear opening at mean low water. Inasmuch as there is no provision made for the accommodation of the electric trolley

traffic, the main shaft on which each bascule leaf rotates may be continuous and not divided into two portions as in design No. 1. This feature simplifies to some extent the matter of the support of the shafts and their connections with the trusses. As already stated, in the general part of this memoir, each half of the bascule is designed to be provided with four 35-horsepower electric motors, the pinions of which engage or gear with a quadrant rack anchored to a cylindrical recess in the masonry. Inasmuch as the sidewalks in this design diverge at the bascule piers in order to pass through the separate arches in the memorial towers, the two outer trusses of the bascule leaves stop at the masonry faces of the two bascule piers and are supported on the adjacent bascule trusses, as shown on the plans.

The 60-foot clear granite masonry approach arches with their concrete steel sheeting are constructed also with five ribs and coffers between, so as to secure efficiency and economy as well for these spans as for the main river arches. The steel parts of the sheeting ribs are deeply embedded in the concrete, and are so disposed as to take practically all the tension which can exist at any point in the ribs. The thin sheeting of the coffers also carries sufficient steel to give it a high degree of strength, although it is assumed to carry no load.

The entire dead and moving loads of all the arch spans are assumed to be carried by the sheeting ribs and by the granite arches, the latter carrying their own weight only. The concrete steel sheeting of the coffers gives to all the arches, both for the river and approach portions of the structure, considerable stiffness and strength which is not directly recognized in the computations, but which exists as an additional margin of strength over and above that shown by the computations.

The foundations of this design are of the same general character as those contemplated for design No. 1, but adapted to the different character of structure and length of spans. In order to economize masonry, however, and to facilitate construction, as well as to secure the best possible disposition of material, longitudinal arches, i. e., parallel to the axis of the structure, pierce each foundation mass, and thus divide each pier and abutment into two parts below the elevation of mean low water. The crown of these dividing arches is never above elevation plus 14. Although the mass of masonry in all the piers of the river spans is ample in itself to carry all the applied loads over these transverse arches, heavy steel girders are embedded in the concrete hearting of the piers above the crowns of the arches to bind the masonry masses below the springing joints into tenacious monoliths. Inasmuch as the masonry in each case offers all the resistance required by computation, the precise amount of duty of these embedded girders can not be computed, but they add very greatly to the strength of the piers and render even slight cracking, from any cause whatever, practically impossible. Their presence adds materially to the general strength and stiffness of the piers without sensible additional cost.

As the plans show, horizontal girders are provided in the piers at the extremities of the bascule span for the purpose of securing the best possible distribution of the horizontal components of the thrusts of the adjacent arches, although computations do not show that they are required. These horizontal girders give great horizontal beam strength to the upper part of the pier, and thus enable the weight of the memorial towers on the bascule piers to act with increased efficiency in giving stability to the piers against the arch thrusts. The foundations of the six piers in the river are designed to be founded on steel pneumatic caissons. The shore piers of the river span, i. e., at the shore extremities of the river portion of the structure, are designed to be constructed within heavy sheet piled inclosures, or within double sheet piled inclosures with suitable filling between carried up to the requisite heights as cofferdams. The latter method is also designed to be employed for all the approach piers and for the abutments. The working chambers of the pneumatic caisson would be filled with No. 1 concrete, and the same concrete would be used for the outer 2 feet in thickness of those portions of all the piers and abutments below mean low water or the surface of the ground. The remaining portions of all the piers and abutments up to the elevation of mean low water, or to the surface of the ground, would be composed of No. 2 concrete, all put in place in the dry.

The concrete of the entire ribs and coffers of the sheeting of both river and approach arches would be of No. 1 concrete.

The roadway and sidewalks of this design, like those of design No. 1, are of sheet asphalt and granolithic material, respectively, laid on concrete floor arches, with the exceptions of the roadway and sidewalk of the bascule span, which are designed to be of either asphaltic cork blocks or wooden blocks, laid in either case on the steel buckle-plate floor, as fully explained heretofore. The floor in this design, like that of design No. 1, and the live load which may come upon it, are supported on rolled I-beam struts or posts properly braced longitudinally and transversely and supported on the concrete steel ribs of the sheeting, all as shown on the plans. The feet of

the struts are suitably designed as pedestals with ample surface for bearing on the masonry.

The plans submitted for this design, showing all the general and detail features of the work, the data used in computations, the greatest resulting stresses, the character of the materials used, and all other information requisite for a complete understanding of all features of the design, are:

Sheet 1.—General elevation and plan.

Sheet 2.—Perspective view of structure.

Sheet 3.—Elevation of river span and adjacent approach span.

Sheet 4.—Transverse sections, showing intermediate piers, abutment or shore piers, and approach piers.

Sheet 5.—Transverse section, showing elevation of bascule tower, side elevation of bascule tower, longitudinal sections, and plans.

Sheet 6.—Plan, elevation, and section of 192-foot clear granite masonry arch with concrete-steel sheeting, one intermediate pier and shore pier or abutment.

Sheet 7.—Plan, elevation, and section of one 60-foot approach span with one pier and approach abutment.

Sheet 8.—Plan, elevation, and section of bascule.

Sheet 9.—Stress and section sheet of 192-foot clear arch.

Sheet 10.—Stress and section sheet of 60-foot clear arch.

Sheet 11.—Stress and section sheet of bascule span.

Sheet 12.—Plan of bascule pier and diagrams of all piers.

DESIGN NO. 3.

The structure shown as design No. 3 has been made, under the terms of your letter of November 6, as a plan in addition to the plans for a bridge requested under the specifications of July 21. It is designed to be a structure for the accommodation of the traffic contemplated under design No. 1; i. e., for a regular street traffic on a 40-foot roadway and two 10-foot sidewalks as the upper deck and an electric-car traffic on a lower deck, placed at an elevation just sufficient to give the requisite amount of clearance for the cars. As the plans show, it is a granite masonry arch structure, with combined concrete and steel sheeting of five ribs, separated by coffers. These general characteristics belong to all the spans of both the river portion of the structure and of the approaches. The arches are all with elliptic soffits, the major axis of the ellipse in each case being twice the transverse or conjugate axis. The rise of each arch at the crown is therefore one-fourth of the clear span. The river arches spring from the elevation of + 4 feet, but in consequence of their elliptic shape the minimum clearance of 24 feet is practically secured at mean low water for the river spans. The soffits at the crowns of all the arches are uniformly 17 feet below the center line of the roadway surface. The grade of the roadway surface for all the river spans is level at an elevation of + 91 feet.

The river portion of the structure is composed of four 283-foot clear span granite masonry arches with concrete-steel sheeting, with intermediate piers 24 feet thick, and one bascule span 212 feet 5½ inches in the clear at mean low water. The face of the Washington approach abutment is at station 5.54, and the elevation of the roadway at that point is + 70.25 feet. The grade, therefore, of the Washington approach is 2½ feet per hundred, or 2½ per cent. For a distance of 869 feet from the face of the shore pier the Washington approach is composed of five granite masonry arches, with combined concrete and steel sheeting varying in clear spans from 190 feet, adjacent to the river, down to 123 feet, adjacent to the embankment approach at the Washington end of the structure. That portion of the Arlington approach adjacent to the river is composed of seven granite masonry arches, with combined concrete and steel sheeting varying from 190-foot clear span down to 99 feet in the clear. The length of this portion of the Arlington approach from the river face of the pier at the shore to the face of the Arlington approach abutment is 1,099 feet. The elevation of the roadway surface at the face of the Arlington approach abutment is about + 64.5 feet, making a grade of roadway surface on the granite masonry arch abutment on the Arlington approach 2½ feet per hundred, or 2½ per cent. The length of the river portion of the structure between face of shore piers is 1,504 feet. Hence the total length of the granite masonry portion of the structure between the faces of the two shore abutments is 3,472 feet.

In forming the plans for this design it was the purpose to adapt the features of the location to the development of the most impressive memorial structure possible, and at the same time so to design it as to make its total cost reasonable for the purposes considered. It was determined, therefore, to use only that material throughout the arches of the entire structure which would give to them the most substantial appear-

ance and be absolutely enduring. It is obviously necessary that the bascule should be made largely of steel, but otherwise the structure is essentially one of masonry, with the exception of the roadway and sidewalk floor on the bascule and the floor supports, which are of steel. The length of spans of the river arches, 283 feet in the clear, is greater than that ordinarily contemplated for masonry arches, and the cost of such arches would probably be prohibitory if constructed in the ordinary manner, entirely of cut-stone masonry, but they become quite feasible when constructed as granite masonry arches with combined concrete-steel sheeting. As in all other masonry arches in designs Nos. 1 and 2, the sheeting in this case has been constructed in five ribs with coffers between.

The thin coffer sheeting is designed to carry no load except its own weight, but, as the plans show, sufficient steel has been embedded in it to enable it to give material stiffness and strength to the ribs. The five ribs of the sheeting are designed to carry all the dead and live load of the spans, with the exception of the granite arch rings, which carry their own weight only. These granite arch rings are interlocked, as shown on the plans, with the concrete masonry of the sheeting. No steel anchors are used to tie the granite ring to the concrete masonry of the ribs, as they are not necessary. They could, however, be readily introduced, and at no appreciable increase of cost. The elliptic ribs and arches are peculiarly adapted to this design, as their center lines practically coincide with the line of resistance in every case. There result, therefore, almost uniformly distributed pressures in any and every transverse section of every rib or arch in the entire structure. No portion of the granite masonry arch or sheeting is subjected to bending or eccentric pressure of material amount.

The sheeting could, therefore, be constructed with perfect propriety of concrete only, but the combination of steel with concrete, the steel being embedded in the latter, possesses such great tenacity and such increased resistance to compression over that of concrete or other masonry alone that steel members have been introduced in the sheeting ribs of this design, although, strictly speaking, they are not needed. Inasmuch as the steel is not needed, its cross-sectional area is not to be determined by computation, yet with any given steel members embedded in the concrete the added resistance to compression produced by the combination is readily computed, and such computations have been carefully applied to the sheeting ribs. By this treatment the plans for this design are made such as to produce a structure which, although heavy as compared with those of shorter spans, is comparatively light, and which may be constructed without unreasonable expense. The plans show in full detail the disposition of all material and the dimensions of all parts. All spans are of the same general type, with dimensions adapted to the varying lengths and the correspondingly varying loads.

The gradually decreasing spans from the river along each approach prevent there being any great unbalanced thrust at any pier and enable piers of relatively small dimensions to be constructed. Indeed, a marked characteristic of this design is the admirable adaptation of each and every part to the structural conditions imposed upon them and to the character of the materials employed.

The bascule is identical in length and all details, both of structure and of actuating machinery, to that used in design No. 1, with the exception that the depth of trusses is 2 feet greater, thus accomplishing a material saving in the amount of steel required. For these reasons no separate bascule plans are submitted with the design. Inasmuch as the explanations relating to the methods of support and operation of the bascule would be the same as used in connection with design No. 1, they need not be repeated here.

The two trolley lines are accommodated also in the same general manner as employed in design No. 1, there being five sheeting ribs. There are five rows of supporting members under the roadway and sidewalk floors and the single space on each side of the center line of columns is adapted to the reception of the two electrical car tracks. The masonry at the crown of the arches is readily adapted to the presence of the electrical conduit required, as shown on the plans. In this manner the electrical traffic is accommodated with perfect facility and without the serious objection which would attach to its presence on the upper deck. If the electrical tracks were placed on the upper deck their operation would not only be objectionable to the pleasure traffic, which it is desired to accommodate, but would also be exceedingly undesirable in its effect upon the appearance of the structure. Further than this, in order to give the desired width of roadway for carriage traffic the width of the structure would be increased, necessarily involving a corresponding increase of cost. For all these reasons it has been thought practically imperative that this alternative plan should be designed to accommodate the electric traffic on the lower deck, as in connection with design No. 1.

Means of communication, agreeable in appearance, either way between the electric tracks and the deck above are provided at the various piers. Indeed, passageways from one deck to another under proper design, as far as they are visible, may be made attractive as architectural features.

The coffer space between the outer two rows of steel columns could be readily adapted, if desired, to form a roadway throughout the entire structure for trucking or other teams not of a pleasure character. This adaptation is not shown on the plans except as in suggestive cross section at one place. This adaptation, however, can be made very readily and with no appreciable increase of cost. The open spandrels in all the spans will make the lower deck light, well aired, and agreeable for the electric traffic or for the suggested teaming traffic, or for any other traffic that may use either space.

As in the two other designs the roadway and sidewalk floors and the electric-car tracks are supported upon steel struts, in this case built of latticed channels and thoroughly braced, both laterally and longitudinally. These struts are designed with pedestals at their lower ends, where they rest upon the ribs of the concrete-steel ribs, so as suitably to distribute the loads.

The sheet asphalt roadway pavement and the granolithic sidewalk pavements are supported on concrete floor arches, but the special asphaltic-cork or wooden-block pavement of the bascule are laid on steel buckle-plate floors, as in the two other designs.

The foundations of the four piers in the river are designed to be constructed on steel pneumatic caissons. All the other piers of the structure, being located in sand and mud, with upper surface not lower than the elevation of about mean low water, are designed to be built in heavy sheet piled inclosures, double, if necessary, with suitable filling between in order to form a cofferdam, as in the case of the corresponding foundations for designs Nos. 1 and 2.

If it is found necessary or desirable the foundations for the two piers at the extremities of the river portion of the structure, one at each shore, can be built on steel pneumatic caissons without essential increase of cost, the depth below mean low water being but 35 feet to bed rock. The working chambers of the pneumatic caissons and the outer two feet in thickness of all piers below the elevation of mean low water, or below the surface of the ground, are designed to be built of No. 1 concrete, and the remaining portions of all the piers and abutments below the elevations named are designed to be made of No. 2 concrete. If it is desirable, the facing of all piers and abutments below mean low water or the surface of the ground may be built of some cheaper stone than granite, such as suitable limestone, without material increase of cost, but it is believed that a facing of this character is not necessary, the No. 1 concrete forming an excellent facing material.

At either extremity of the granite-arch portion of the structure the two electric-railway lines may be brought out to the embankment approach in precisely the same manner described in design No. 1. They may easily be laid out, one on each side of the embankment, and carried on lateral extensions or berms to such grade or connections as may be desired. By this method the electric street-car traffic may be kept entirely from the roadway and sidewalks. If, however, it is desired, the two electric-car tracks may be carried on their straight alignment through the masonry of each abutment and up to the grade of the roadway surface at the center of the latter, the two halves of the roadway surface and the two sidewalks diverging sufficiently to accomplish this purpose. The plans submitted with this design are:

Sheet 1.—General elevation and plan.

Sheet 2.—Perspective view of structure.

Sheet 3.—Elevation of river span.

*Sheet 3*a.—Elevation of an approach span.

Sheet 4.—Transverse sections showing intermediate piers, abutment or shore piers, and approach piers.

Sheet 5.—Transverse section showing elevation of bascule tower.

Sheet 6.—Side elevation of bascule tower, longitudinal sections and plans.

Sheet 7.—Plan, elevation, and section of a 283-foot clear, granite masonry span, with combined concrete and steel sheeting, with one pier and shore abutment.

Sheet 8.—Plan, elevation, and section of one approach, granite masonry span, with combined concrete and steel sheeting with intermediate pier and abutment for Washington approach.

Sheet 9.—Stress and section sheet for 283-foot combined concrete and steel rib.

Sheet 10.—Stress and section sheet for one approach, combined concrete and steel rib.

Sheet 11.—Drawing for bascule pier and diagrams of all piers.

ESTIMATE OF COST OF DESIGN NO. 1.

The estimated costs of the various portions of the structure under this design are as follows:

Superstructure:		
4 283-foot steel arches, 8,184,000 pounds steel, at 4 cents	$327, 360	
2,400 linear feet cornice, at $5	12, 000	
		$339, 360
Bascule:		
3,136,000 pounds steel, at 4 cents	125, 440	
Motors, counterbalance, machinery, etc	88, 000	
450 linear feet cornice, at $5	2, 250	
		215, 690
36 46-foot approach spans, 4,370,000 pounds steel, at 4 cents	175, 000	
19,150 cubic yards concrete, at $8	153, 000	
7,200 cubic yards granite masonry, at $30	216, 000	
		544, 000
Total superstructure		1, 099, 050
Substructure:		
1 bascule pier—		
1,860,000 pounds steel, at 4 cents	74, 400	
5,780 cubic yards excavation, at $3	17, 340	
5,780 cubic yards concrete, at $8	46, 240	
3,164 cubic yards granite masonry, at $27	85, 400	
1,630 cubic yards No. 1 concrete, at $6	9, 780	
18,841 cubic yards No. 2 concrete, at $4. 60	86, 800	
Cost of 2 bascule piers, at	319, 960	639, 920
1 intermediate pier—		
477,000 pounds steel, at 4 cents	19, 080	
2,065 cubic yards excavation, at $3	6, 195	
2,000 cubic yards concrete, at $8	16, 000	
974 cubic yards granite masonry, at $27	26, 300	
775 cubic yards No. 1 concrete, at $6	4, 650	
3,376 cubic yards No. 2 concrete, at $4. 60	15, 550	
Cost of 2 piers, at	87, 775	175, 550
1 shore pier—		
8,450 cubic yards excavation, at $2	16, 900	
1,814 cubic yards granite masonry, at $27	49, 000	
985 cubic yards No. 1 concrete, at $6	5, 910	
9,000 cubic yards No. 2 concrete, at $4. 60	41, 400	
Cost of 2 shore piers, at	113, 210	226, 410
1 approach pier—		
1,062 cubic yards excavation, at $2	2, 124	
249 cubic yards granite masonry, at $27	6, 720	
400 cubic yards No. 1 concrete, at $6	2, 400	
560 cubic yards No. 2 concrete, at $4.60	2, 575	
Cost of 34 piers, at	13, 819	470, 000
1 abutment—		
5,000 cubic yards excavation, at $2	10, 000	
802 cubic yards granite masonry, at $27	21, 700	
870 cubic yards No. 1 concrete, at $6	5, 200	
7,032 cubic yards No. 2 concrete, at $4.60	32, 300	
Cost of 2 abutments, at	69, 200	138, 400
Total substructure		1, 650, 400

Pavements, embankments, and railings, etc.:		
37,000 square yards roadway and sidewalk pavements	$75,150	
10,500 linear feet curb, at 50 cents	5,250	
11,100 linear feet railings, at $10	111,000	
270,000 cubic yards embankment, at 30 cents	81,000	
6,500 square feet overhead railroad crossings, at $4	26,000	
		$298,400
Total structure		3,047,850
Bedford limestone masonry of bascule towers and monuments at shore piers and abutments		280,000
Sculptures, lamp-posts, and ornaments—		
48 statues, at $5,000	240,000	
8 monuments, at $20,000	160,000	
8 spandrels, at $5,000	40,000	
8 groups of statuary, at $20,000	160,000	
4 groups of statuary, at $10,000	40,000	
4 victories, at $10,000	40,000	
4 lamp-posts, at $5,000	20,000	
28 lamp-posts, at $2,000	56,000	
		756,000
Total towers and architectural features above balustrade		1,036,000
Total cost of entire work		4,083,850

ESTIMATE OF COST OF DESIGN NO. 2.

The estimated costs of the various portions of the structure under this design are as follows:

Superstructure:		
6 192-foot granite arches—		
3,319,480 pounds steel, at 3½ cents	$116,100	
11,850 cubic yards concrete, at $8	94,800	
4,878 cubic yards granite masonry, at $30	146,340	
		$357,240
Bascule:		
1,610,000 pounds steel, at 4 cents	64,400	
Motors, counterbalance, machinery, etc	54,000	
340 linear feet cornice, at $5	1,700	
		120,100
30 60-foot approach spans—		
2,400,000 pounds steel, at 3½ cents	84,000	
20,100 cubic yards concrete, at $8	160,800	
7,260 cubic yards granite masonry, at $30	217,800	
		462,600
Total superstructure		939,940
Substructure:		
1 bascule pier—		
5,000 cubic yards excavation, at $3	15,000	
1,163,000 pounds steel, at 4 cents	46,520	
5,000 cubic yards concrete, at $8	40,000	
1,920 cubic yards granite masonry, at $27	51,700	
1,512 cubic yards No. 1 concrete, at $6	9,100	
17,468 cubic yards No. 2 concrete, at $4.60	80,200	
Cost of 2 bascule piers, at	242,520	485,040
1 intermediate pier—		
1,040 cubic yards excavation, at $3	3,120	
240,000 pounds steel, at 4 cents	9,600	
1,040 cubic yards concrete, at $8	8,320	
685 cubic yards granite masonry, at $27	18,500	
628 cubic yards No. 1 concrete, at $6	3,768	
1,873 cubic yards No. 2 concrete, at $4.60	8,600	
Cost of 4 piers, at	51,908	207,632

Substructure—Continued.		
1 shore pier—		
8,350 cubic yards excavation, at $2	$16,700	
1,814 cubic yards granite masonry, at $27	49,000	
980 cubic yards No. 1 concrete, at $6	5,880	
8,900 cubic yards No. 2 concrete, at $4.60	41,000	
2 shore piers, at	112,580	$225,160
1 approach pier—		
1,250 cubic yards excavation, at $2	2,500	
320 cubic yards granite masonry, at $27	8,620	
416 cubic yards No. 1 concrete, at $6	2,496	
660 cubic yards No. 2 concrete, at $4.60	3,040	
Cost of 28 piers, at	16,656	465,000
1 abutment—		
5,000 cubic yards excavation, at $2	10,000	
802 cubic yards granite masonry, at $27	21,700	
870 cubic yards No. 1 concrete, at $6	5,200	
7,368 cubic yards No. 2 concrete, at $4.60	33,900	
2 abutments, at	70,800	141,600
Pier girders—		
449,000 pounds steel, at 4 cents		17,900
Total substructure		1,542,332
Pavements, embankments, and railings, etc. (as per design No. 1)		298,400
Total structure		2,780,672
Bedford limestone masonry of bascule towers and monuments at shore piers and abutments		230,000
Sculpture, lamp-posts, and ornaments:		
52 statues, at $5,000	$260,000	
8 spandrels, at $5,000	40,000	
12 bas-relief, at $5,000	60,000	
2 quadrigas, at $50,000	100,000	
8 monuments, at $30,000	240,000	
Lamp-posts	50,000	
		750,000
Total towers and architectural features above balustrades		980,000
Total cost of entire work[1]		3,760,672

ESTIMATE OF COST OF DESIGN NO. 3.

The estimated costs of the various portions of the structure under this design are as follows:

Superstructure:		
4 283-foot granite arches—		
4,760,000 pounds steel, at 4 cents	$190,400	
21,572 cubic yards concrete, at $8	172,400	
6,848 cubic yards granite masonry, at $30	205,440	
		$568,240
Bascule (as per design No. 1)		215,690
12 approach spans—		
3,345,000 pounds steel, at 4 cents	134,000	
950,000 pounds steel, at 3 cents	28,500	
19,650 cubic yards concrete, at $8	157,200	
8,650 cubic yards granite masonry, at $30	259,500	
		579,200
Total superstructure		1,363,130

[1] See foot note on page 50.

Substructure:		
1 bascule pier—		
1,865,000 pounds steel, at 4 cents	$78,600	
6,250 cubic yards excavation, at $3	18,750	
6,200 cubic yards concrete, at $8	49,600	
3,895 cubic yards granite masonry, at $27	105,000	
2,147 cubic yards No. 1 concrete, at $6	12,882	
28,318 cubic yards No. 2 concrete, at $4.60	130,500	
Cost of 2 piers, at	395,332	$790,664
1 intermediate pier—		
331,000 pounds steel, at 4 cents	13,240	
1,430 cubic yards excavation, at $3	4,290	
1,400 cubic yards concrete, at $8	11,200	
933 cubic yards granite masonry, at $27	25,180	
3,330 cubic yards No. 1 concrete, at $6	19,980	
3,322 cubic yards No. 2 concrete, at $4.60	15,300	
Cost of 2 piers, at	89,190	178,380
1 shore pier—		
9,050 cubic yards excavation, at $2	18,100	
1,789 cubic yards granite masonry, at $27	48,400	
6,460 cubic yards No. 1 concrete, at $6	38,760	
9,061 cubic yards No. 2 concrete, at $4.60	41,700	
Cost of 2 piers, at	146,960	293,920
10 approach piers—		
39,200 cubic yards excavation, at $2	78,500	
6,470 cubic yards granite masonry, at $27	175,000	
13,250 cubic yards No. 1 concrete, at $6	79,300	
31,070 cubic yards No. 2 concrete, at $4.60	143,200	
		476,000
1 abutment—		
10,000 cubic yards excavation, at $2	20,000	
1,420 cubic yards granite masonry, at $27	38,300	
2,899 cubic yards No. 1 concrete, at $6	17,340	
8,260 cubic yards No. 2 concrete, at $4.60	38,000	
2 abutments, at	113,640	227,280
Piles and grillage under Arlington abutment wing walls		2,450
Total substructure		1,968,694
Pavements, embankments, and railings, etc. (as per design No. 1)		298,400
Total structure		3,630,224
Bedford limestone masonry of bascule towers and monuments at shore piers and abutments		280,000
Sculptures, lamp-posts, and ornaments:		
8 monuments, at $20,000	$160,000	
4 spandrels, at $5,000	20,000	
12 groups of statuary, at $20,000	240,000	
2 quadriges, at $50,000	100,000	
Lamp-posts	50,000	
		570,000
Total towers and architectural features above balustrade		850,000
Total cost of entire work		4,480,224

The preceding estimates of costs[1] exhibit in considerable detail the values of the various grades of work included in the three designs. They are believed to be in full detail for the purposes of this competition. If, however, it is desired, I am prepared to submit any additional details that may at any time be required.

Respectfully submitted,

Wm. H. Burr,
Civil Engineer.

Lieut. Col. Chas. J. Allen,
Corps of Engineers, U. S. A.

[1] The total cost of entire work (design No. 2)	$3,760,672
Deduction (see appended letter)	80,000
Total (corrected) cost of entire work	3,680,672

LETTER OF MR. EDWARD P. CASEY, ARCHITECT.

NEW YORK, *February 9, 1900.*

DEAR SIR: I find that in making up the cost of design No. 2 Mr. Burr estimated it upon the basis of 18 arches in the Virginia approach. This number was subsequently changed to 15, which are shown in the general drawing.

This, allowing for cost of additional embankment, would make a net reduction in the estimate of cost of this structure of $80,000, which should be deducted from the amount given in the memoir. In all three variations of our design the draw opening is made larger than the limit called for, as we found on studying the proportioning of the openings that the bridge had a much more harmonious appearance when all the openings between piers approached similarity in dimensions.

When the additional advantage for the passage of vessels and the reduced cost of the whole structure by diminishing the length of river spans was considered, the enlarged draw was adopted without hesitation. In the absence of Mr. Burr I should be happy to furnish any information the board may desire in reference to the design and hope they will not hesitate if I can be of any service to them either by coming on to Washington or writing an explanation of doubtful points in the designs if such be found.

Very respectfully, yours,

EDWARD P. CASEY.

Lieut. Col. CHAS. J. ALLEN,
Corps of Engineers, U. S. A.

P. S.—As it was not mentioned in the memoir it might be stated that the eight groups of statuary on the two bascule towers of designs No. 1 and No. 2 could properly represent such subjects as patriotism, courage, fortitude, justice, concord, progress, etc., to be subsequently decided upon.

E. P. C.

MEMOIR SUBMITTED WITH THE DESIGNS OF MR. WM. R. HUTTON.

LIST OF DRAWINGS.

PLAN NO. 1.

1. Perspective view looking northwest from the Washington side.
2. General plan and elevation, scale 1–360, 2 sheets.
3. Front and side elevation of central drawspan; also section through 550-foot span, scale 1–96.
4. Plan and elevation of pedestals at entrance of bridge.

Section through crown of masonry arch adjoining 550-foot span, scale 1–96.
Elevation of 200-foot span.
Elevation of 550-foot span.

5. Plan and elevation of arch over Water street, scale 1–96.
6. Section through drawspan, scale 1–96.
7. Transverse section of 550-foot span at crown and in sixth panel.

Elevation of pedestal and base of rib with section at sixth panel, scale 1–96.

8. Section of 200-foot span at center of second panel.

Section of drawspan showing lifting girder.
Stress diagram of intermediate truss.
Stress diagram of central truss.
Elevation of lifting girder.
Plan of lift bridge showing bracing of lower chords, scale 1–96.

9. Diagram of apparatus for lifting drawspan.

PLAN NO. 2.

10. General plan and elevation, scale 1–360 (two sheets).
11. Elevation and section of central drawspan, scale 1–96.
12. Elevation of 274-foot span, Washington side.

Section through 274-foot span at second panel.
Section through masonry arch adjoining 200-foot span.
Elevation of half of 200-foot span and adjoining masonry arch Arlington side.
Elevation of pier adjoining skew span over Water street, scale 1–96.

13. Transverse section of 274-foot span at crown and in second panel.

Transverse section of 204-foot span at crown and in second panel.
Longitudinal section of 204-foot span, scale 1–96.

PLAN NO. 1.

14. *Plans Nos. 1 and 2.*—Longitudinal section of masonry arch, Washington side; transverse section on A B and C D.

Plan No. 2.—Longitudinal section of masonry arch, Arlington side; transverse section A B, scale 1–96.

15. Bascule; drawspan, scale 1–96.

16. Of bracing and general details, scale 1–96.

MEMOIR.

In submitting plans for the Memorial Bridge it is proper to state the motives which have controlled its principal features. The work is a monument to American patriotism, a tribute not only to the great men of the nation, but to all who have by sacrifice contributed to the country's good. In this view it rises above the utilitarian, and becomes a structure worthy of the people who build it and the merit it commemorates. The plans show for themselves how far this result has been obtained.

But the general features of the bridge must be based upon practical considerations. Not only is it a monument; it must be adapted to the public use, and to this all other features must be subordinated.

The question of elevation and grade first presents itself. In view of the length of the grade and the character of the asphalt roadbed, 1½ per cent is thought to be the limit for convenient use. At the initial point, the intersection of Twenty-third street with New York avenue, an elevation of 60 feet above water surface can be reached by easy grades on either line of approach. From this point the upper roadway of the bridge rises to 88 feet above water at the draw. The requirement that the metal arches be not less than 24 feet above water was an embarrassment, and a temptation to use a steeper grade in order to give more rise to the metallic arches. From the draw a uniform light grade extends to the Alexandria road at Arlington.

After the grade the drawspan demanded attention. A draw revolving in a horizontal plane was clearly out of harmony with the conditions of the scheme. Any other form required high towers or piers on either side, and rendered this the central feature of the bridge. In considering the question a bascule seemed to be prohibited by the subway for the electric railway, as well as by the requirement of an asphalt roadway on concrete and a granolithic sidewalk. A lift bridge only seemed to meet the conditions, and one such was adopted. The piers for the lift bridge must permit the span to be raised sufficiently for the passage of the tallest masts beneath it, and the bridge and its hoisting gear are very heavy (240 tons at each corner of the span).

Being the central feature, it was further accentuated by connecting the piers by arches, which carry a rectangular dome of open work in copper, supported by light iron framework.

Artistically there was but one position possible for such a structure, the middle of the main river, but it is also satisfactory in view of the interests of navigation. It is easily accessible from either direction. It lies entirely within the proposed 800-foot channel to be dredged, and partly within that of 400 feet in width.

The central draw with its large piers being fixed in position, it seemed most natural to connect them with either shore by an arch of a single span. The distance between piers is 550 feet; between pier centers, 534 feet, with a rise of 37.1 feet. More rise was greatly desired, but as the minimum height of springing line above water was fixed by the specifications—greater rise could only be given by raising the grade—which was considered even less desirable. The result, however, is not unsatisfactory.

From the initial point the bridge is on embankment to the permitted limit, nearly as far as Water street. The electric railway, approaching preferably from E street, rests upon a bench on the slope of the embankment until it passes into its permanent position in the subway of the bridge. Water street must be crossed by an oblique arch of masonry of 100-foot span on the axis of the bridge. The great width of pier on the east side, caused by the obliquity of the arch, has been skillfully adapted by the architect to contain a stairway from the surface of Potomac Park, giving access to the sidewalk of the bridge. This is followed by five elliptical arches of masonry, over which light and view are given to the electric railway by an arcade of small masonry arches. The masonry structure terminates at the river wall. Masonry over the main river was not permitted by the first specification, and the second left too little time for the careful study of a masonry structure, after so much progress had been made with one of steel.

From the river wall one of the large steel arches reaches a pier of the draw span. This, in conformity with original specification, has an opening of 126 feet. It is a

truss span, conforming to the general section of the work, resting at each pier upon a "lifting girder," to the ends of which the hoisting ropes are attached. It is arranged to rise 135 feet above the waier if it should be required to go so high. Up to this time the tallest vessel that has passed the site was 113 feet in height.

From the draw piers another arch of 550 feet extends to Analostan Island, terminating in a substantial pier. From this point symmetry demands a repetition of the arcade over Potomac Park which is therefore introduced. In view of the uncertain future of Little River, whether it shall be filled up or made a waterway, assisting effectively in the discharge of the floods of the Upper Potomac, four steel spans, of 200 feet, reach across it to the Virginia shore. In this connection it may be remarked that the slope of water surface in the last great flood was 6 feet from Aqueduct Bridge to Easbys Point, and little over a foot from that place to Long Bridge, a distance nearly twice as great.

From the abutment terminating the bridge proper, at the Virginia shore, the roadway is upon embankment. The electric railway leaves the subway at this point and lies on the slope of the embankment until it reaches ground of sufficient height where it is left to shift for itself. The roadway crosses by a bridge the branch of the Pennsylvania Railroad, and the Washington, Alexandria and Mt. Vernon electric railway, which runs on the side of the Alexandria road, is to be deflected to the north and pass under this, the memorial bridge. The latter terminates in a smaller plaza at the Alexandria road, just outside one of the memorial gates.

Before passing to the details of construction the architect's notes upon the scheme of decoration are quoted below:

"The chief features of the composition have been made to express its emblematic meaning and to afford the best opportunities for appropriate decoration.

"The bridge is to be a memorial to American patriotism.

"The central part, the draw span, consists of four massive piers united by great stone arches, on whose voussoirs are placed the arms of the individual States which form the structure of the Republic, and whose keystones bear the national arms, so typifying the dominating and binding rôle the nation plays in the fabric built up by the States. From these four piers great curved steel trusses rise into the form of an open metal dome, its crest bearing a richly decorated standard for the nation's flag (itself the ideal emblem of American patriotism). At the base of each pier on either side of the central span are cut waters fashioned into galley prows, bearing groups of trophies emblematic of naval victories.

"The approaches to the two great river spans are flanked by masonry towers, each crowned with groups of sculpture, and bearing tablets for inscriptions, names of battles, of episodes in the nation's history worthy of such commemoration, names of patriots, heroes of war and peace.

"The interruption of symmetry caused by the skew arch spanning Water street has been taken advantage of to introduce on the south side a masonry stair approach from the level of Water street up to that of the bridge. By repeating a corresponding motive on the north side, at the diagonally opposite side of the Water street arch, a return to the original symmetry of pier and arch spacing is effected.

"Around the circular plaza at the main approach to the bridge from the Washington side are placed statues to represent the thirteen original States of the Union. A monument, group, or fountain is suggested in the center of the plaza."

The first works requiring attention are the masonry arches from Water street to the river wall. The piers are founded upon the rock by means of cofferdams formed of a single (or if found necessary), a double row of tongued and grooved sheet piling, braced as the excavation advances, the cofferdam to be filled with Portland cement concrete of the best quality to within a few feet of the surface, whence it shall be faced with stone. The entire exterior is to be faced with granite with the ring stones of the same.

I should make the soffits of arch stones of variable depth, not necessarially extending through the arch, and making up its thickness with concrete. The soffits would be very handsome if made with good brick, but this is not permitted by the specification. In the interior the arches are finished to a tangent to the extrados meeting the tangent from the adjacent arch in an anticlinal axis, which forms the drainage line between the two, from which an outlet pipe is laid.

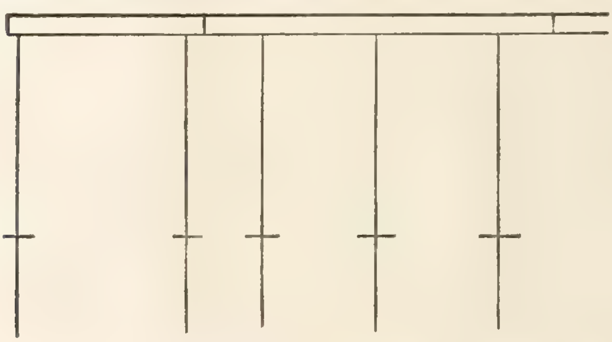
The back of the arch is to be plastered smooth, then coated with asphalt. It was the first intention to carry the electric railway tracks upon brick arches between the interior walls—but it is thought preferable to fill the space under them with what the French call sand-beton, which is a very poor concrete made largely of sand with enough cement or lime to make it cohere, and to place upon this 3 or 4 feet of earth in which the railway company may lay their tracks according to their own best judgment. In every case a course of small stones is to be laid upon the asphalt as a drain to carry to the drainage axis any water which may find access.

The exterior wall of the subway is formed of granite arches of 5 feet span, upon piers 3 feet wide and 2½ feet thick. These must be dressed fine on all sides. The interior wall will be of brick faced with white brick to give light and color to the subway. The width of the subway is too great, and the side walls too thin to permit it to be covered by an arch of brick. Steel I beems are therefore laid accross it, and these support brick arches whose thrust is parallel to the side wall. The other interior walls, three in number, support the roadway by means of arches as shown by the plans and sections. The soffits of the main arches are true ellipses—the arches are 4 feet thick at crown and 7 feet at half the rise of the arch, they are formed largely of concrete.

The masonry arcade is terminated at the sea wall by a pier of masonry 50 feet thick. Even with the thrust of the granite arch this pier is hardly sufficient and three walls to connect with the foundation of the next northerly pier were designed, but I observe have been ommitted by the draftsman.

The steel arch is 8 feet 5 inches deep; the flanges are double at top and bottom; the outer flange 24 inches wide, the inner ones 12 inches. Their sections for maximum stress are given on page 15. The columns are spaced 12 feet; those on the outer ribs are 20 inches wide and 12 inches deep. The interior columns are formed of 10-inch channels, latticed. The vertical stiffeners on the arch rib were a reluctant concession to the architect.

The railway is carried by a floor beam of plates and angles—12-inch 31.5 pounds I-beams are sufficient to carry the tracks, but an 8 inch rail can not be placed on top of a 12-inch beam; a timber is therefore inclosed between the 12-inch beam, and a stiffened plate 20 inches high and the rails are attached to the timber. The light beam to carry the conductors and insulators lies midway of the rails. The subway floor is braced horizontally except where so near the arch flange that the bracing of the latter takes its place. The arches are braced in pairs. The weight of the outer and the second ribs is considerable, and about the same; that of the interior ribs is less. If the ribs were spaced at equal distances an excessive load would be thrown on the second rib on each side which would already carry half the subway and its load. To avoid this the floor beam of main floor is jointed just clear of the flange of the second rib, so that the load on it is symmetrical, and the interior piers are so spaced that the end of the main floor beam next the joint is carried as a cantilever.



The main roadway of concrete and asphalt is laid on buckle plates, riveted to 12-inch I-beams, which rest upon and are riveted to a cross girder 20 inches deep. The braces and connections are shown by the sheet of details.

The four outer arches are those which carry the subway and its load, the latter assumed to be a continuous train of cars 40 feet long, each with its load weighing 50,000 pounds. The pressure of these arches upon the pin is for each, a little less than 4,000,000 pounds. This is carried by a pin 20 inches in diameter and 40 inches long which rests upon a pedestal of cast steel with a base upon the masonry of 5 by 8 feet.

The masonry of the skew back will be of the best granite, extended into the pier and arranged to distribute the pressure over larger surfaces. The pressure of the interior ribs is somewhat less.

The main piers are ample to take the thrust of the steel arch and to carry the weights and machinery of the lift span. This with its concrete floor weighs 960 tons, 240 at each corner. It is to be raised by 6 ropes of the best steel wire at each corner, which are attached to the ends of a lifting girder under the ends of the trusses. These cables in groups of three pass over two sheaves 12 feet in diameter; 3 ropes and a small operating rope on each sheave run horizontally about 12 feet to another pair of similar sheaves and thence down to the counter-weights in a well in the pier. The counter-weights are blocks of cast iron 4½ by 1½ by 25 feet, and should be inciosed in a pair of frames attached to the outer counter-weignts, by means of which they can be confined and guided, leaving each weight to exert its full tension on the ropes.

There are two drums as shown; an ordinary trolley motor attached to each drum, say of 60 horsepower each, will be sufficient to control the machinery. It is assumed that the current will be furnished from other sources not on the bridge.

The foundations of these large piers are estimated as sunk in four caissons, two to each pier, the parts of which will be connected by arches.

My own intention was to build them by means of a crib-cofferdam at about the same cost.

The arches connecting the piers at their summit are of masonry; they should be built of the lightest material, and would probably admit of lightening the piers considerably. The question was discussed whether they should be made of metal or of stone, and the latter was selected as more monumental, although the reduced weight of the piers in the other case would in a certain measure reduce the cost.

The dome rests upon a pair of diagonal steel arches upon which the other ribs rest at one end, the other end being supported by the masonry arch. No complete computation has been made of these steel-braced arches, but they have been examined sufficiently to assure their stability.

The remarks made upon the 550-foot span apply equally to the span beyond the draw, and the same is true of the masonry arcades in corresponding positions relatively to the central draw towers.

The pier between the last masonry arch and the first steel arch of 200 feet seemed at first sight too light, but investigation showed it to be sufficient.

There is nothing more to be said about the four 200-foot spans over Little River. The piers are rather large, made so for architectural effect, which is justified by the great depth at the crown—in every case 23 feet, whether the span be great or small, as that depth is required for the subway and the two floors.

The pier forming abutment on the Virginia shore has a short wing to support the railway as it leaves the bridge; from this point the railway rests on a bench on the slope of embankment until ground at its own level is reached, whence it finds its own way.

The specifications call for a second plan similar to the first, except that the electric railway should be on the one main roadway. As it was supposed that the motive for this was reduction of cost, plan No. 2 has been otherwise modified from No. 1. The grade has been lowered to reduce the height of the piers; the piers were also to be diminished in thickness by a slight increase in the span of the smaller steel arches, and two arches each of 272 feet span replace each one of the large arches of No. 1.

The piers at the junction of the masonry with the steel spans on both sides of the river are considerably smaller, and the piers of the draw span are reduced in size. A bascule draw replaces the lift bridge. As all the new methods for bascules are patented, I have not hesitated to adopt the patent of Mr. Montgomery Waddell, in which the half span rests and moves upon a certain number of large fixed friction rollers, each composed of a shell moving upon a ring of live rollers between it and the interior cylinder, which turns on axles. It is proposed to lay the floor of this bascule with wood block pavement, somewhat as on the Tower Bridge. I observed, too late, that the gearing had not been shown on the drawing. It consists merely of a pinion gearing into the large segments on the end of each truss. The pinion may readily be geared up to any desired speed, and a trolley motor of 50 horsepower on the last shaft will be sufficient to operate the bascule.

The estimate of cost seems very large. The pricess are intended to provide for the best material and workmanship in every class. Even for such work the prices are large, but I submit them without revision.

The designs have been made in conformity with Mr. Theodore Cooper's specifications for railway bridges, and the coefficients therein prescribed have been used in the computations, being slightly exceeded in the computations for the ribs of the large arches. In Mr. Cooper's railway specifications the unit stresses on the material are placed very low to provide for the annually increasing weight of locomotives and trains. These low unit stresses increase the weight of material in the bridge.

The stresses given in the table herewith are all compressive. There is no tension on any part of the ribs.

The computations have been made for the bridge fully loaded with live and dead load, with the live load covering half the span, and for a change of temperature of 60° F. each way from the mean.

Sections of the large arch were taken at every third panel point, beginning with the first. The numbers of the sections are those of the respective panel points.

The 200-foot arch was computed at ten sections, equally spaced without regard to the point of application of the loads.

If plan No. 1, submitted herewith, should be constructed, the substitution of cast steel for steel plate in the ribs of the main arches, as has been done in the new bridge Alexander III, in Paris, would add to the monumental character of the work; or even cast iron might be substituted, as it is not exposed to tension.

Other improvements and economies have suggested themselves during the progress of the work which need not be referred to here.

I am indebted to the active and skillful cooperation of Mr. Ernest Flagg, whose work shows for itself in the drawings.[1]

Respectfully,

WM. R. HUTTON,
Consulting Engineer.

Col. CHARLES J. ALLEN,
Corps of Engineers, U. S. A.

Some further notice should be taken of the decorative work.

The capitals of the columns of the arches are of cast iron, as are the bases and the panelled archivolt above the capitals. An ornamental disk covers the flange at its junction with the column or post and this decoration follows down the stiffeners and in great part conceals them. The wreaths on the web of the arch are to be of stamped copper, as are all the other minor decorations. Generally, the cornices and the larger parts will be of cast iron, the finer and more delicate parts of copper. The balustrade on the metal arches is estimated of cast iron, with some allowance for the introduction of bronze.

The stone cutting has been estimated as cut in the best manner, especially moulded work and carvings.

W. R. H.

APPROXIMATE ESTIMATE OF THE COST OF CONSTRUCTION.

[After the plan of Mr. William Rich Hutton.]

PLAN NO. 1.

Foundations, including cofferdams and 123,484 cubic yards of excavation	$399,320	
96,030 cubic yards of masonry, at $9	864,270	
158,667 cubic feet of granite facing below water, at $1.50	238,000	
		$1,501,590
182,915 cubic yards masonry, at $6 (rubble and concrete)		1,097,490
8,640 cubic yards concrete, backing of arches, at $6		51,840
12,050 cubic yards, concrete, under asphalt, in roadway, subway and plazas		72,300
12,076 cubic yards concrete filling (sand-beton), at $3		36,228
1,421,695 cubic feet granite facing		4,375,000
Bricks, 309,884 cubic feet, at 40 cents		123,954
43,840 square yards asphalt pavement, at $2		87,680
6,330 feet of granite balustrade on masonry, at $90		569,700
Structural steel, 20,062,000 pounds in arches, at 5 cents		1,003,100
356,664 pounds in lift bridge, at 5 cents		17,833
72,160 pounds in bridge over Pennsylvania Railroad		3,608
Steel beams in roof of subway, 580,480 pounds		29,024
Steel frames for copper dome, 264,400 pounds		13,220
Ornamental ironwork, less balustrade		282,000
Balustrade on steel spans, 2,220 feet, at $40 (both sides)		88,800
Copper dome, shields, etc		100,000
Lamps and globes and electric work		440,000
Excavation and embankment, 122,286 cubic yards, at 50 cents		61,143
Total cost		9,954,510

No complete estimate has been made of plan No. 2.[1]

The structural steel work will cost	655,000
Other ironwork, exclusive of lamps and globes	180,000
Lamps of cast iron and globes	45,000

[1] In response to a written inquiry the following telegram was received March 5, 1900: "Approximate cost plan two, five and three-quarter millions.—(W. R. Hutton.)"

Maximum stresses and flange sections of arch of 550 feet between piers, 4 outer ribs.

[Pressure on pin 3,958,000 pounds.]

Number of column.	Upper flange section. Stresses.	Upper flange section. Section.	Lower flange section. Stresses.	Lower flange section. Section.
	Pounds.	*Sq. inch.*	*Pounds.*	*Sq. inch.*
1st	1,918,650	110.5	1,913,478	110.2
4th	2,051,123	118.1	1,974,092	113.7
7th	1,973,440	134.7	1,795,525	121.4
10th	2,612,401	150.5	2,251,691	129.7
13th	2,757,812	158.8	1,721,334	99.1
16th	2,420,296	139.4	2,040,850	117.5
19th	2,154,283	124.1	1,736,863	100
21st	2,014,442	116	1,036,495	59.7
22d	2,015,714	116	1,642,500	94.5

Stresses, etc., in three interior ribs 550-inch arch.

[Pressure on pin 3,225,770 pounds.]

1st	1,563,699	90.1	1,559,484	89.8
4th	1,671,665	96.3	1,608,884	92.6
7th	1,608,353	110.6	1,553,352	89.5
10th	2,129,106	122.6	1,835,128	105.7
13th	2,247,616	129.5	1,402,887	80.8
16th	1,972,541	113.6	1,664,107	95.8
19th	1,753,740	101	1,415,543	81.5
21st	1,641,770	94.5	1,844,743	106.2
22d	1,642,806	94.6	1,338,637	77.1

R. 17,660 pounds square inch.

PLAN NO. 1.

Stresses and sections of 200-foot arch with subway, with maximum load, 4 outer ribs.

	Upper flange. Stresses.	Upper flange. Sections.	Lower flange. Stresses.	Lower flange. Sections.
	Pounds.	*Sq. inch.*	*Pounds.*	*Sq. inch.*
1st	811,800	48.7	715,200	42.9
2d	857,200	51.4	647,800	38.9
3d	874,700	52.5	617,300	37
4th	888,400	53.3	582,600	34.9
5th	881,400	52.8	575,600	34.5

R. 16,667 pounds.

Stresses and sections of ribs in 200-foot arch with subway, 4 outer ribs with dead load, and live load on half the arch.

1st	743,500	44.6	401,900	25.1
2d	820,400	49.2	308,000	18.5
3d	822,500	49.3	266,500	15.4
4th	736,600	44.2	365,600	21.9
5th	572,400	34.3	520,400	31.2
6th	334,100	20	769,100	47.1
7th	219,500	13.2	899,500	54
8th	219,400	13.1	909,400	54.5
9th	372,200	22.3	802,700	48.2

R. 16,667 pounds.

LETTER OF MR. WILLIAM R. HUTTON, CONSULTING ENGINEER.

NEW YORK CITY, *February 13, 1900.*

COLONEL: If not too late, I beg to explain that my statement as to the height of the masts of vessels passing the site of the memorial bridge assumed that their topmasts would be lowered as is customary.

If I am not mistaken, the limit fixed for the East River bridges, in New York, and for the Washington bridge over the Harlem, was 135 feet.

The arched way and piers of memorial bridge permit a lift of 150 feet or thereabouts.

Respectfully,

WM. R. HUTTON,
Consulting Engineer.

Col. CHAS. J. ALLEN,
Corps of Engineers, U. S. A.

MEMOIRS SUBMITTED WITH THE DESIGNS OF MR. GEORGE S. MORISON.

DESCRIPTIVE MEMOIR.

This bridge is to be a monument; it is to be a memorial to American patriotism. The design must combine the elements of strength and durability with those of grace and beauty, and may be decorated with such ornamentation as fitly applies to the purpose to which this bridge is dedicated. While it is intended that this bridge shall serve a useful purpose in connecting the public buildings and parks of Washington with the historic hills of Arlington on the other side of the Potomac, this is not its main object.

A monument suggests perpetuity; it commemorates something which is worthy of preservation; its construction and material must imply durability. The idea of duration can be agreeable only when combined with the idea of rest. A monument should seem to be in a state of eternal repose.

A bridge, in the common acceptation, is a commercial tool built to convey traffic across a river.

If the memorial monument is combined with the utilitarian bridge, one or the other must predominate. The idea of the useful bridge must disappear in the impression of the monument, or the idea of the monument must be lost in the useful bridge. In the design submitted an endeavor has been made to make the monument supreme and to remove commercial appearances as far as possible, even sacrificing utility when there is danger of marring the memorial idea.

The one material suitable for monumental work is masonry; it is the only form of construction made of really durable material. The ordinary elements of the atmosphere do not act destructively on the better classes of stone, brick, and mortar. In metal structures constant care and protection are required to prevent oxidation and oxidation means rapid destruction.

The design submitted proposes to span the Potomac with a structure consisting entirely of masonry, this being the memorial bridge proper. As the condition of a draw, which is necessarily a mechanical contrivance, is entirely inconsistent with the restful ideas of a monument it has been excluded entirely from this monumental structure.

The dimensions of the masonry structure are made such that it would be able to pass the entire flood discharge of the Potomac within its limits. The cross section of the Potomac at the Aqueduct Bridge during floods is estimated to be at 34,600 square feet. At the site of the proposed bridge extreme high water is 13.3 feet above low-water line. If we assume an average depth of 26.7 feet below low water, which is about 8 feet above the average depth of bed rock, a width of 900 feet would give a cross section of 36,000 square feet, which is a little more than that at the Aqueduct Bridge. This width has been adopted in the design submitted and divided into 5 spans, averaging 180 feet each, which is within convenient limits of masonry construction. These 5 spans are separated by 4 piers about 20 feet thick, making the length of structure, including piers, 980 feet. At each end is placed an abutment of sufficient dimensions to resist the thrust of the arches, these abutments being 40 feet thick, and making the total length of the monumental structure 1,060 feet.

The weakness of this design, as a monumental work, lies in the thrust of the arches which the abutments must resist. To reduce the signs of this labor, the spring line of the arch has been placed as low as was thought right, namely, at the level of extreme high water, and the abutments are accentuated by projections at each end,

which are surmounted with columns, intended to emphasize the importance and strength of the abutments.

A slight crown is given to the bridge, the center being made 3.25 feet higher than either end. The ordinates of the vertical curve are divided above low water proportionally into the three parts, the height of the spring lines of the arches above low water, the rise of the arches, and the thickness above the crown of the arches. The shape of the arches is always kept in the same proportion, the length of each arch being proportional to its rise. The spans of the five arches are, respectively, 177.22 feet, 181.38 feet, 182.78 feet, 181.38 feet, and 177.22 feet. These slight changes of dimensions are perhaps overrefinements, and the structure might be built with five equal arches of 180 feet span, but the slight crown in the bridge is not only believed to add to its beauty, but it forms a vertical curve connecting the two gradients of the two approaches.

Leaving the memorial bridge in itself as complete a unit as possible, the monumental element has been dropped in the other parts of the design, the drawbridges and the approaches being made mechanical tools adapted to commercial considerations. On each side of the river and at each end of the memorial bridge is placed a Scherzer rolling lift draw, the draw having a clear opening of 64 feet, and opening as single bascule rolling away from the memorial bridge. Each approach consists of a skeleton steel viaduct, the Washington approach extending across Potomac Park and the Arlington approach across the low Potomac flats on the south side of the river.

Provision is made for street cars simply by making the roadway 20 feet wider than called for in the specifications. There are three reasons for adopting this arrangement: First, the width specified (60 feet) is too narrow to give the massive effect which should belong to a memorial work; second, there is no way in which a street railroad could be carried on a lower grade than a highway across the memorial structure without destroying the graceful appearance of the arches; third, the position of the street-car tracks, between the footways and the main driveway, enables the street-car passengers to take or leave the cars on the bridge, gives the passengers in those cars a view up and down the Potomac, and leaves a full, unobstructed width of roadway between the two tracks; this roadway can be separated from the street cars by a curb and fence if it is thought desirable.

The plans submitted are therefore for a structure 80 feet wide between railings, which provides for street-car tracks, while estimates have also been made for a structure 60 feet wide without these tracks. It is believed, however, that the wider structure shoud be built in either event, and that if no street-car tracks are allowed a width of 80 feet divided into two sidewalks of 16 feet each and a driveway 48 feet wide is no greater than ought to be provided on a memorial bridge of this kind.

In this connection it seems right to add that the arrangement of approaches in the plans submitted, though required by the specifications, does not seem to the designer the proper solution of the problem. The specifications require an openwork structure over Potomac Park, so as not to interfere with the park, and an openwork structure over the flats, so as not to interfere with the water discharge over those flats. So far as keeping the park open is concerned, it is impossible to maintain a park under a bridge with a solid floor, such as is required for street travel. The shadow caused by this floor destroys the grass below it and prevents the growth of vegetation. A neat appearance can be obtained only by constructing a gravel way the entire width of the structure, and this is not consistent with park ideas. So far as the Arlington approach is concerned, it seems desirable to exclude the flow of water from the flats, confining the entire flood discharge of the river to the bridge proper. This would maintain a deep channel through the bridge, and the waterway would still be fully equal to that of the Aqueduct Bridge above. It would allow the flats on the south side of the Potomac to be filled and converted into solid, dry ground, a very important sanitary consideration. The designer believes that the proper form of approach is a solid earth embankment, with slopes flat enough to be maintained as grassy lawns, decorated with such flowers and shrubs as a landscape gardener might recommend. A slope of two horizontal to one vertical would meet these conditions, and the embankments could be made decorative features of the park.

It should also be considered whether it may not be possible to dispense with the draws. If the solid earth embankments could be brought up to the abutments at each end of the masonry bridge the memorial appearance would be complete; the abutments backed by these artificial mountains would have apparently unlimited powers of resistance; the idea of labor would entirely disappear. The only traffic which goes above the bridge is taken to the wharves of Georgetown, navigation being absolutely closed by the Aqueduct Bridge 1.25 miles above the proposed bridge. The center arch is 182 feet long in the clear and nearly 60 feet above low

water; steamboats and barges could pass through the arches to these wharves, while sailing vessels can be built which could adapt their masts to these conditions. It would seem as if it should be possible to make some arrangement with the wharf owners of Georgetown under which, after, say twenty years, the right to have masted vessels to go to them would be relinquished. Meanwhile a small draw of a single opening, perhaps 45 feet, would answer all purposes. Such a draw could be located at the Virginia end of the memorial bridge and the Virginia approach might be built in the form of a temporary timber structure with the understanding that both the draw and the timber work were to be replaced subsequently with a solid earth embankment. Even if, however, it is considered necessary to maintain the two draws provided in the design, the earth embankments are much cheaper and believed to be in every respect much better than the open structure shown on the plans and required by the specifications.

MEMORIAL BRIDGE.

Foundations.—The two abutments and the four piers of the memorial bridge are founded on pneumatic caissons. The caissons of the abutments are 160 feet long and 48 feet wide, and those of the piers 114 feet long and 25 feet wide. No detail plans are given showing the construction of these caissons, as it is a class of work which is well understood, and there are several varieties of good caisson details for such work. These plans would properly be worked up at the time the contract is let. The depths to rock are moderate, and the work of a class which can easily be contracted. It would probably be wise to make the caissons of steel filled with concrete, though timber caissons would give good results especially for the piers. The average elevation of the bedrock being taken at —35, and the elevation of the top of the caissons being —23, the volume of each of the abutment caissons would be 92,160 cubic feet, and that of each of the pier caissons 34,200 cubic feet. The total volume of the six caissons and their filling would then be as follows:

	Cubic feet.
2 abutments, at 92,160 cubic feet	184,320
4 piers, at 34,200 cubic feet	136,800
Total	321,120

The cost of this work, including both material and sinking, has been estimated at 50 cents per cubic foot, which is believed to be large as the material penetrated is soft and the depths moderate. The foundations could probably be fitted to the rock without much rock excavation. On this basis the cost of these foundations would be $160,560.

In the case of the bridge 60 feet wide each foundation would be 20 feet shorter than above stated and the quantities would be as follows:

	Cubic feet
2 abutments, at 80,640 cubic feet	161,280
4 piers, at 28,200 cubic feet	112,800
Total	274,080

The cost of these foundations, estimated at 50 cents per cubic foot, would be $137,040.

Piers and abutments.—The outline shapes of the piers and abutments are given on sheet 8, which also gives the stresses existing in these pieces of masonry. Both piers and abutments are built with pointed ends of a form which passes the current of a river with least disturbance; they are built with a batter of one in 24 all around from the top of the caisson to elevation +1 (above low water), above which plane they are plumb. It is proposed to build the piers of limestone with a granite facing above elevation—3, while the warped surfaces outside of the arches at each end would also be granite. The pier masonry is supposed to terminate at the point marked A on the plans. Each pier contains 3,135 cubic yards of masonry, of which 435 yards is granite-face masonry and the remainder, 2,700 cubic yards, is limestone; the total cost of the masonry of one pier is estimated as follows:

2,700 cubic yards limestone, at $12	$32,400
435 cubic yards granite, at $27	11,745
Total	44,145

The abutments, in which mass to resist the thrust of the arches is the principal consideration, are designed to be built of concrete, with a limestone facing, except between elevation —3 and the spring line of the arch, where the facing will be granite.

In order to secure weight the abutments are carried up solid to the surface of the roadway. Each abutment contains 13,390 cubic yards, of which 655 cubic yards is granite facing, 960 cubic yards limestone facing, and the balance concrete. The estimated cost of the masonry in one abutment is:

655 cubic yards granite facing, at $27	$17,685
960 cubic yards limestone facing, at $12	11,520
11,775 cubic yards concrete, at $6	70,650
Total	99,855

The estimated cost of the masonry in the piers and abutments will then be as follows:

4 piers, at $44,145	$176,580
2 abutments, at $99,855	199,710
Total	376,290

In the case of the narrower bridge, each pier and abutment will be 20 feet shorter and the quantities will be as follows:

365 cubic yards granite facing, at $27	$9,855
2,160 cubic yards limestone facing, at $12	25,920
One pier	35,775
585 cubic yards granite facing, at $27	15,795
820 cubic yards limestone facing, at $12	9,840
9,570 cubic yards concrete, at $6	57,420
One abutment	83,055

Making the cost of the entire masonry:

4 piers, at $35,775	143,100
2 abutments, at $83,055	166,110
Total	309,210

Arches.—As already stated, the clear spans of the arches vary from 177.22 feet in the side arches to 182.78 feet in the center arch. The intermediate arch, having a span of 181.38 feet, has been taken as practically an average of the three and worked up in detail. The dimensions and stresses in this arch are shown on sheet 7.

It is proposed to build the arches of limestone, the intrados to be fine pointed work throughout, the faces of the voussoirs on each side of the bridge to be bush hammered with chamfered edges, and the extrados to be finished with a smooth Portland cement surface. The thickness of the arch varies from 5 feet at the center to 7 feet at the edge of the pier. These dimensions are not so great but that every stone in the arch could be made to reach completely through from intrados to extrados. It is hardly thought, however, that this would be necessary, but the face stones on each side should reach completely through, and at least one-third of the remainder of the work should consist of headers reaching through. The five arches would be built simultaneously all on centering, which centering would probably be built in three spans of about 60 feet each, resting on pile piers.

It is proposed to use lead bearings about 1 foot wide at the center of the arch and similar bearings 18 inches wide at the joint so designated on the stress sheet, these lead bearings being intended to fix the line of the strain from dead load only, the joints to be subsequently filled solid with cement mortar.

The stress sheet (sheet 7) has been worked up on the supposition that the resultant curve of strains from dead load only passes through the center of these lead joints. The resultant curve of pressure from dead load only is shown by a continuous line; the resultant curves of pressure from dead and live loads combined are shown by broken lines of different characters; the series of small circles indicates the position of the resultant curve from the weight of the arch only before the upper works are built. The work has been specially designed with reference to keeping the resultant curve on the center line of the arch and to render this result more perfect voids have been left at six points in the concrete filling and cast-iron weights inserted at five others. The resultant curves under all conditions fall well inside of the middle third.

The estimated amount of masonry in one arch, including the portion between the lower lead joint and that already estimated as pier masonry, is 3,850 cubic yards;

the estimated cost of this masonry, including centering, is $20 per cubic yard, making the cost of each arch $77,000, and of the five arches $385,000.

If these arches were built of granite the cost would be increased about $15 per cubic yard. As the maximum pressure is 51,000 pounds per square foot, or 354 pounds per square inch (that occurring only at one edge), the stresses are well within the safe limits of limestone masonry, and even the best quality of brick masonry laid in Portland-cement mortar.

In the case of the narrower structure the amount of masonry in each arch will be sixty-two eighty-seconds of the above, or 2,910 cubic yards, making the cost of each arch, at $20 per cubic yard, $58,200 and the cost of the five arches $291,000.

Spandrels.—The upper works above each arch are divided into 12 equal panels, the length of these panels varying from 15.1 feet in the side arches to 15.56 feet in the central arch. The three central panels over the crown of each arch are built up solid to the level of the gravel under the roadway. The four panels on each side are built in the form of full centered arches supported on piers 4 feet thick. A similar arrangement is continued across the piers, there being a single arch over each pier; it is not continued across the abutments, as the weight of a solid construction is required there. By this arrangement the weights on the haunches are reduced to meet the conditions of the stress sheet.

The ends of the piers are closed, the starlings surmounted by semicircular shafts, as shown on sheet 9. The starlings of the abutments are surmounted by hollow pieces of ornamental masonry, solid construction occupying the central 82 feet of width.

It is proposed to build the piers in this spandrel work of limestone, though there are no serious objections to building them of brickwork, the ends to be limestone and the sides of each pier to be finished in light brick. The arches themselves can be made in the same way, either of limestone or of brick with limestone ends. The shafts over the piers should be of limestone of the same character as that used in the main arches; the ornamental work at the end of each abutment should be of the same material. The spandrels between the small arches would be finished with a plain limestone face, which would be surmounted by an ornamental cornice, finishing the sides of the roadway and carrying the railing above. The entire work would be leveled off to an elevation 2 feet below the finished roadway with a cheap quality of concrete, and this concrete filling should extend to the surface under the sidewalks. The space between the concrete and the roadway pavement would be filled with a gravel, of which it is estimated that there will be about 3,000 cubic yards.

The amount of limestone or brick masonry in this spandrel work in one span, measured from center to center of piers, will average 2,975 cubic yards. There will be in each span 1,650 cubic yards of concrete filling, or 8,250 in all. There will be 220 tons of cast iron in each span, or 1,100 tons in all. There will be 228 cubic yards of limestone masonry in the shafts at the two ends of each of the four piers and 1,056 cubic yards in the hollow construction at the two ends of each abutment.

The total amount of masonry of this class will therefore be as follows:

	Cubic yards.
5 spans of spandrel work at 2,975 cubic yards	14,875
4 piers at 228 cubic yards	912
2 abutments at 1,056 cubic yards	2,112
Total	17,899

Estimating this masonry at $10, the concrete at $6, and the gravel at $1 per yard, and the iron at $15 a ton, the cost of the spandrel work will be as follows:

17,900 cubic yards limestone at $10	$179,000
8,250 cubic yards concrete at $6	49,500
3,000 cubic yards gravel at $1	3,000
1,100 tons cast iron at $15	16,500
Total	248,000

This estimate is for the bridge with an 80-foot floor; for the structure with a 60-foot floor these quantities are reduced to the following:

14,390 cubic yards limestone, at $10	$143,900
6,500 cubic yards concrete, at $6	39,000
2,000 cubic yards gravel, at $1	2,000
830 tons cast iron, at $15	12,450
Total	197,350

Structural work —The foregoing items make the complete structural work of the memorial bridge, the estimated cost of which may be summarized in the following table:

	80 feet.	60 feet.
Foundations	$160,560	$137,040
Piers and abutments	376,290	309,210
Arches	385,000	291,000
Spandrels, etc	248,000	197,350
	1,169,850	934,600

It is believed that this is a full estimate of the cost of the structural portton without pavement or ornaments.

Roadway.—The specifications require that the sidewalks shall be 10 feet wide and shall have a granolithic surface, while the roadway shall have an asphalt surface of the class used in the District of Columbia, this pavement to have a concrete foundation. The concrete filling under the sidewalks is provided for in the structural work; the concrete foundation of the roadway is included in the price of the asphalt pavement.

It is proposed to carry the surface drainage of the roadway into the conduit in which the electric conductors would be laid, this plan being adopted because with the tracks where they are it would be difficult to prevent a large portion of the water entering this conduit at any rate. At short intervals (probably every small pier) a pipe would be built into the masonry by which this conduit could be drained, one of these being shown on sheet 11. This water would be discharged on the extrados of the main arches and could be carried down on this surface and thence into drains built in the main piers and finally discharged into the river; this is a simple detail which need not be worked out now. If no street railway tracks are laid the gutter would be drained in the same way. If it is thought objectionable to take this water into the slots some other detail of drainage can easily be arranged.

The estimated cost of a single foot of roadway for the bridge 80 feet wide is:

Sidewalk surface, 20 square feet, at 15 cents	$3
Asphalt pavement, 60 square feet, at 20 cents	12
Total	15

Or $15, 900 for the entire bridge.

In the case of the bridge 60 feet wide, there will be 20 square feet less of asphalt pavement, reducing the cost to $11 per linear foot, or $11,660 for the whole length of the bridge.

Ornamental work.—The ornamental work is shown on sheets 9, 10, and 11. The principal features are the cornices, the railing, the special work already alluded to over the piers and abutments, a bronze eagle at the crown of the central arch, and the four columns which emphasize the abutments. Spaces are provided at the ends of the abutments for groups of statuary, which perhaps would most appropriately be made of bronze and placed there on special occasions. Each of the four columns terminates in a globe on which is perched a bronze eagle with spread wings. Provision is made for eight lamp-posts, two over each pier.

The cost of this ornamental work will depend very largely on the care with which it is done and the amount of detail. A general provision of $200,000 is allowed to cover this work, this including no material except that in the railing and the four columns and the bronze work.

Cost of memorial bridge.—Summarizing the foregoing estimates, we have a total cost of the memorial bridge as follows:

	80 feet wide.	60 feet wide.
Structural work	$1,169,850	$934,600
Roadway	15,900	11,660
Ornamental work	200,000	200,000
Total	1,385,750	1,146,260

This estimate could be varied greatly, according to the materials which should be selected and the kind of work done. The whole structure could be built entirely of granite, or of marble if the nation sees fit to make a sufficient appropriation. The design is based on using for this work Indiana limestone, except where specially stated, which combines durability with ease of working, and whose color harmonizes with a work of this class. With this material it is safe to say that the cost of the bridge would be inside of $1,400,000 for the structure, 80 feet wide, and about 15 per cent less for the structure 60 feet wide.

DRAWBRIDGES.

The drawbridges, as designed, are exactly alike and are placed on each side of the memorial structure; each is built on a grade of 1.3 per cent. The design selected is the Scherzer rolling lift bridge, this being chosen because it is a form of bascule bridge which has given good results in actual practice, and because it can be so designed that all the mechanical features are below the roadway, the surface of which which will be left clear and unbroken except when the draw is open. The Scherzer bridge is built both as a single and a double bascule; a single bascule is selected because the length of the span is such that it can easily be crossed by a single arm, and by allowing the arm to roll away from the Memorial Bridge the features are kept entirely distinct from the monument.

The draw rolls on a masonry pier, the general design of which is given on sheet 12. This pier is a plain piece of masonry founded on a pneumatic caisson, the pier, however, being chambered to save masonry and weight. It is proposed to build it entirely of limestone. The estimated cost of this pier is as follows in the bridge 80 feet wide:

Caissons and filling, 52,730 cubic feet, at 50 cents	$27,865
Masonry, 6,525 cubic yards, at $10	65,250
Total	93,115

In the bridge 60 feet wide the cost will be as follows:

Caissons and filling, 42,770 cubic feet, at 50 cents	$21,385
Masonry, 5,130 cubic yards, at $10	51,300
Total	72,685

The design of the mechanical structure of the draw is given on sheets 13, 14, and 15, these designs being prepared in the office of the Scherzer Rolling Lift Bridge Company in Chicago. The estimated weight of metal in each of the two draws, including the buckled plates and everything below them, is as follows:

	80 feet.	60 feet.
	Pounds.	*Pounds.*
Floor system	244,000	183,000
Trusses, including rolling segment, etc	280,000	210,000
Stationary work	120,000	90,000
Structural steel	644,000	483,000
Machinery	224,000	168,000
Counterweights	980,000	735,000
Total	1,848,000	1,386,000

The estimated cost of these draws, as given by the Scherzer Rolling Lift Bridge Company (with an addition for the buckled plates which it did not include), is $73,000 for the structure 80 feet wide and $55,000 for the structure 60 feet wide, this including machinery and electric equipment.

To this must be added the pavement and railing on a length of 106 feet. Although the concrete base must be anchored down, the cost of the pavement will be practically the same as on the memorial bridge, making $1,590 for the wide bridge and $1,166 for the narrow bridge. The railing will be of cast iron, the details being shown on sheet 11. This railing weighs 150 pounds per foot of fence, or 300 pounds per foot of bridge, and is estimated to cost $6 per foot of bridge, making $636 for one draw. The total cost of the mechanical structure of one draw, including pavement

and railing, will be $75,226 for the wider bridge and $56,802 for the narrower bridge.
The total cost of each draw may then be estimated as follows:

	80 feet.	60 feet.
Pier	$93,115	$72,685
Mechanical structure	75,226	56,802
Total	168,341	129,487
Two draws	336,682	258,974

Besides this, provision must be made for a navigable channel on each side of the memorial structure. The general outlines of this channel are shown on sheet 1. The excavation falls entirely within the present limits of the river and simply means the widening of the proposed 800-foot channel. The amount of additional excavation required for this purpose is estimated to be 293,000 cubic yards, which, at 10 cents a yard, would cost $29,300, making the entire cost of the draws and the channels of the two respective bridges as follows:

	80 feet wide.	60 feet wide.
Draw proper	$336,682	$258,974
Excavation	29,300	29,300
Total	365,982	288,274

The cost of the draws is about one-quarter that of the memorial bridge.

WASHINGTON APPROACH.

The Washington approach is complicated by the crossing of Water street. With this exception the general form adopted for both approaches is that of a steel viaduct supported on concrete piers capped with granite, each pier resting on 12 piles which are driven to rock. In the case of the wide bridge each viaduct bent is built with three vertical posts and in the case of the narrower bridge with two vertical posts, there being a single pier under each post.

The cost of one of the piers supporting the viaduct is estimated as follows:

395 linear feet piles, at 20 cents	$79.00
44 cubic yards concrete, at $6	264.00
57 cubic feet granite coping, at $1	57.00
500 pounds anchor bolts, at 3 cents	15.00
1,000 pounds base casting, at 2 cents	20.00
Excavation, etc	15.00
Total	450.00

The details and dimensions of this viaduct structure are given on sheets 16 and 17. The girders are supported on rocking expansion bearings on the line of the neutral axis. Each successive pair of bents is braced into a tower, the length of the tower being slightly less than that of the intermediate spans, so that the length of the girders between bearings is everywhere the same.

The Washington approach includes 826 lineal feet of viaduct of this description, the estimated weight of which is as follows:

	80-foot bridge.	60-foot bridge.
	Pounds.	*Pounds.*
12 towers and bracing	1,122,300	870,576
26 spans of girders	1,319,900	736,984
Floor, including crossbeams and buckled plates	1,371,800	1,047,740
Total steel	3,814,000	2,655,300
Costing, at 4 cents per pound erected	$152,560	$106,212

Water street is crossed by a deck bridge of 160 feet span resting on masonry piers. The estimated cost of this bridge is as follows:

80-foot bridge.

1,410 cubic yards masonry, at $10	$14,100
7,500 lineal feet piles, at 20 cents	1,500
500,000 pounds steel, at 4 cents	20,000
Total	35,600

60-foot bridge.

1,022 cubic yards masonry, at $10	$10,220
5,700 lineal feet piles, at 20 cents	1,140
375,000 pounds steel, at 4 cents	15,000
Total	26,360

The pavement on the viaduct is the same as the pavement on the draw; the railing is also the same. The estimated cost, therefore, of the railing and pavement is $21 per lineal foot for the broad structure and $17 for the narrow structure. The total length of the Washington approach from draw to abutment is 986 feet, making the cost of the pavement and railing $20,706 for the broad structure and $16,762 for the narrow structure.

The viaduct terminates at the north end in a masonry abutment containing 1,560 cubic yards in the wider structure and 1,320 cubic yards in the narrower structure, the masonry of this abutment being estimated to cost $8 a yard, making the cost of the two structures $12,480 and $10,560, respectively.

Beyond the abutment is an embankment estimated to contain about 10,000 yards, the material for which will be taken from a cut beyond.

The detail estimated cost of the Washington approach with the 80-foot roadway is then as follows:

72 small piers, at $450	$32,400
Steel viaduct	152,560
Water street bridge	35,600
Pavement and railing	20,706
Abutment	12,480
Embankment	1,500
Total	255,246

And for the 60-foot roadway:

48 small piers, at $450	$21,600
Steel viaduct	106,212
Water street bridge	26,360
Roadway and railing	16,762
Abutment	10,560
Embankment	1,500
Total	182,994

If we substitute for this viaduct a solid earth embankment 100 feet wide on top, with slopes two horizontal to one vertical, such an embankment would contain about 302,000 cubic yards of earth, and can be built for about $80,000, besides the modifications which must be made in draw piers to support the end embankment.

ARLINGTON APPROACH.

The Arlington approach includes 1,845 linear feet of viaduct like that described above, the estimated weight of which is as follows:

	80-foot bridge.	60-foot bridge.
	Pounds.	*Pounds.*
29 towers	2,712,225	2,103,900
59 spans of girders	2,948,195	1,646,224
Floor, including crossbeams and buckled plates	3,064,110	2,340,396
Total steel	8,724,530	6,090,520
Costing, at 4 cents per pound, erected	$348,981	$243,621

The cost of railing and pavement, at $21 and $17 per linear foot, for the respective structures will then be $38,745 for the broad structure and $31,365 for the narrow structure.

The viaduct terminates at the south end in a masonry abutment containing 2,700 cubic yards in the wider structure and 2,300 cubic yards in the narrower structure. Assuming this to cost $8 per yard, the cost for the two structures will then be $21,600 and $18,400, respectively.

Beyond this abutment is an embankment estimated to contain 60,000 cubic yards in the wider structure and 50,000 cubic yards in the narrower structure, the cost of which may be taken at $12,000 and $10,000, respectively, for the two cases.

The estimated cost of the Arlington approach with the 80-foot roadway is, then, as follows:

174 small piers, at $450	$78,300
Steel viaduct	348,981
Pavement and railing	38,745
Abutment	21,600
Embankment	12,000
Total	499,626

And for the 60-foot roadway—

116 small piers, at $450	52,200
Steel viaduct	243,621
Pavement and railing	31,365
Abutment	18,400
Embankment	10,000
Total	355,586

If we substitute for this viaduct a solid earth embankment 100 feet wide on top with slopes two horizontal to one vertical, such an embankment would contain about 820,000 cubic yards of earth and can be built for about $215,000, besides the modifications which must be made in draw piers to support the end embankment.

SUMMARY.

To the items already considered an addition must be made to cover the depression of the street-car tracks on the Arlington side. The cost of depressing these tracks will depend very largely on the details of the method in which it is done, and this method would be determined by the action taken in allowing street cars to cross the memorial bridge. As this work will at any rate form but a small part of the total cost, it is thought best not to submit an estimate in detail, which would be of little value, but to let it be included in the item which is added to cover engineering and contingencies.

The total cost of the entire structure may then be taken as follows:

	80-foot bridge.	60-foot bridge.
Memorial bridge	$1,385,750	$1,146,260
Draws	365,982	288,274
Washington approach	255,246	182,994
Arlington approach	499,626	355,586
Total	2,506,604	1,973,114
Engineering and contingencies, 10 per cent	250,660	197,311
Total cost	2,757,264	2,170,425

In a general way the cost of the entire structure, if the draws are omitted and a solid earth embankment substituted for the open approaches, may be estimated as follows, the bridge being assumed as 80 feet wide and the narrower bridge not being considered:

Memorial bridge	$1,400,000
Additions to abutments	200,000
Washington approach	80,000
Arlington approach	215,000
Total	1,895,000
Add 10 per cent	189,500
Total cost	2,084,500

In other words, a bridge of this kind could be built for about $2,100,000 although this cost could be very greatly increased by more elaborate work and the use of higher priced materials.

In concluding this descriptive memoir it is only right to call attention to the share the designer's assistant, Mr. Wilson Fitch Smith, has had in the work, all the plans having been prepared under his immediate charge. Credit should also be given to Mr. William Emerson, the architect, who has worked out the features which are specially decorative.

GEO. S. MORISON.

JANUARY 31, 1900.

Lieut. Col. CHAS. J. ALLEN,
Corps of Engineers, U. S. A.

LIST OF PLANS.

		Scale.
1.	Map and profile	1/2000
2.	General elevation and plan	1/360
3.	General elevation and plan	1/360
4.	General elevation and plan	1/360
5.	General elevation and plan	1/360
6.	General elevation and plan	1/360
7.	Stress sheet of arch	1/48
8.	Stress sheet of abutments and piers	1/96
9.	Central arch, elevation and plan	1/96
10.	Abutment plan and elevations	1/96
11.	Cross section of floor, details of railings	1/48 and 1/12
12.	Draw pier	1/96
13.	Stress sheet of draw	1/96
14.	Plan and elevation of draw closed	1/48
15.	Elevation of draw open and cross section	1/48
16.	80-foot viaduct, elevation and cross section	1/48
17.	60-foot viaduct, elevation and cross section	1/48
18.	End abutments and Water street bridge piers	1/96
19.	General elevation and plan continuous sheet	1/360
20.	Perspective of memorial bridge.	

JANUARY 31, 1900.

APPENDIX G G G.

WASHINGTON AQUEDUCT, INCREASING THE WATER SUPPLY OF WASHINGTON, INVESTIGATING THE WATER SUPPLY OF WASHINGTON, AND WASHINGTON AQUEDUCT FILTRATION PLANT, DISTRICT OF COLUMBIA.

REPORT OF LIEUT. COL. A. M. MILLER, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1900.

OFFICE OF THE WASHINGTON AQUEDUCT,
Washington, D. C., July 28, 1900.

GENERAL: I have the honor to forward herewith the annual reports for Washington Aqueduct, increasing the water supply of Washington, D. C., investigating water supply of Washington, D. C., and Washington Aqueduct, D. C., filtration plant.

Very respectfully, your obedient servant,

A. M. MILLER,
Lieut. Col., Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

G G G 1.

WASHINGTON AQUEDUCT.

Appropriations for the Washington Aqueduct are applied to the improvement, maintenance, and repair of all of those parts of the water supply that have been placed under the supervision of the Chief of Engineers, except the new reservoir near Howard University and the tunnel connecting it with the distributing reservoir. These are the masonry dam across the Potomac at Great Falls, the works there for regulating the supply to the conduit, the Conduit road from Great Falls to Washington, a distance of about 14 miles, the conduit from Great Falls to the distributing reservoir, the three reservoirs for supplying the city, the mains for delivering water from the reservoirs into the city's distributing system, and the two bridges for carrying the mains across Rock Creek.

The water supply is taken from the Potomac River at Great Falls, about 14 miles above the city.

At this point a masonry dam extends across the river from the Maryland to the Virginia shore. Its total length is 2,877 feet, and the width of its crest in the Virginia channel and across Conns Island is 8 feet

3 inches and in the Maryland channel 7 feet 9 inches. In 1895–96 the crest of the dam was raised from a reference of 148 feet above mean tide at the Washington Navy-Yard to 150.5 feet above the same datum plane.

The top of the mouth of the feeder of the conduit at Great Falls is at a reference of 149 feet and the bottom at a reference of 139.5 feet.

The water passes from the feeder through the gatehouse and into the conduit, which at this point has a reference of 152 feet at the interior surface of the crown of the arch.

The slope of the conduit is uniform between the gatehouse at Great Falls and the distributing reservoir and is 9 inches in 5,000 feet.

The conduit is circular in cross section, and for the greater part of its entire length is 9 feet in diameter and composed either of rubble masonry plastered or of three rings of brick, but where the soil in which it was built was considered particularly good the inner ring of brick was omitted and the diameter is 9 feet 9 inches. Where the conduit passes as an unlined tunnel through rock, the excavation was sufficient to contain an inscribed circle 11 feet in diameter.

The lengths of the conduit and its connections are as follows:

Length of feeder at Great Falls, 256 feet.

Area of cross section at mouth, 157.45 square feet.

Length of conduit between gatehouse at Great Falls and north connection of Dalecarlia Reservoir, 47,896.5 feet; least diameter, 9 feet.

Length of by-conduit around Dalecarlia Reservoir, 2,730.5 feet; diameter for 625 feet, 8 feet; for rest of distance, 9 feet.

Length of conduit between south connection of the Dalecarlia Reservoir and north connection of the distributing reservoir, 10,149.87 feet; diameter of conduit, 9 feet.

Length of by-conduit around the distributing reservoir, 2,274.35 feet; diameter, 7 feet.

At the distributing reservoir the water passes into 4 cast-iron mains 48 inches, 36 inches, 30 inches, and 12 inches in diameter, respectively.

The Dalecarlia Reservoir has a storage capacity of about 150,000,000 gallons, is practically without paved slope wall, is perfectly protected against pollution from the drainage of the surrounding country, and is provided with a spillway, the reference of the bottom of which is 146.5 feet. The reference of the interior surface of the crown of the arch of the conduit at the north connection of this reservoir is 143.77 feet and at the south connection 143.39 feet. The distance between these points, measured along the line of flow of the water across the reservoir, is about 3,550 feet.

The distributing reservoir has a storage capacity of about 150,850,000 gallons and is divided by a puddled and paved wall, through which is a passageway which can be closed with stop planks, into two sections, containing 97,600,000 and 53,250,000 gallons, respectively.

The interior surface of the crown of the arch of the conduit at the north connection of this reservoir has a reference of 141.87 feet.

The Georgetown high-service reservoir is circular in plan and has an available capacity of about 1,500,000 gallons. The reference of its water surface when the reservoir is full is 220.5 feet. Although this reservoir is under the charge of this office, the duty of keeping it filled by pumping devolved upon the water department of the District of Columbia until it was taken out of service, November 17, 1897, at the request of the Commissioners of the District of Columbia, the Fort

Reno Reservoir and the pumping service having rendered its further use inadvisable except in case of emergency.

In addition to the three reservoirs already mentioned, which form a part of the aqueduct system, there is another reservoir, built and controlled by the Commissioners of the District of Columbia, called the Fort Reno Reservoir, with a capacity of about 4,500,000 gallons, the reference of its water surface when the reservoir is full being about 420 feet. This reservoir is supplied with water taken from the supply mains by the U street pump.

The Dalecarlia and distributing reservoirs supply that part of the District which lies below 90 feet above datum. The areas lying between the levels of 90 and 220 feet above datum are supplied by pumping from the U street station directly into the distributing mains, and by the use of the new Brightwood Reservoir, having at present a capacity of 15,000,000 gallons, the Georgetown high-service reservoir being held as a reserve supply. The areas having a greater elevation than 220 feet above datum are supplied from the Fort Reno Reservoir.

It will be observed, therefore, that the total present storage capacity of all reservoirs is a little less than 322,000,000 gallons, or about six days' normal supply.

Until the average daily consumption of water becomes considerably greater than at present the reference of the surface of the water at the lowest stage of the Potomac will be about 151 feet at the mouth of the feeder at Great Falls, about 146.75 feet at the Dalecarlia Reservoir, and 146 feet at the distributing reservoir.

The total supply of water which the present conduit can safely furnish, without a pressure dangerous to its safety, is 76,000,000 gallons per diem. This, however, necessitates the lowering of the distributing reservoir to reference 144, thus involving a loss of head of 2 feet at that point of distribution.

The following statement shows the operations upon the aqueduct and its accessory works during the fiscal year, and their condition at its close:

GATEHOUSES, WATCHMEN'S QUARTERS, AND OTHER BUILDINGS.

The watchmen's houses at Great Falls, Dalecarlia Reservoir, and the distributing reservoir were repaired, and the watchman's house at Great Falls was painted; a 24-foot by 14-foot addition to the aqueduct office was constructed and painted, and a timber shed and stable were constructed at the distributing reservoir. Gatehouses and storehouses were covered with a wash of Portland cement and the inside of gatehouses whitewashed.

THE RESERVOIRS.

The grounds at the Dalecarlia Reservoir, the distributing reservoir, and the high-service reservoir were cleaned and all low or marshy places in the shore of the Dalecarlia Reservoir were filled in and graded. Two hundred and fifty cubic yards of sand and mud were removed from the channels around the Dalecarlia Reservoir. About 300 feet of the channel leading from the north connection of the Dalecarlia Reservoir was deepened 2 feet by dredging.

A line of posts was set across the bottom lands of Little Falls branch a few hundred feet above the Dalecarlia Reservoir drainage shaft for the purpose of preventing drift and trash piling up at the shaft during floods.

The following table gives the fluctuation from and including the year 1894–95 to date, June 30, 1900, of the level of the water in the distributing reservoir:

Year.	Lowest.	Date.	Highest.	Date.	Range.
	Feet.		*Feet.*		*Feet.*
1894–95	141.45	February, 1894	145.55	March, 1895	4.1
1895–96	144.15	July, 1895	145.95	April and May, 1896	1.8
1896–97	145.08	January 30, 1897	146.08	November 29, 1896	1
1897–98	145.65	February 2, 1898	146.10	April 27, 1898	.45
1898–99	144.55	February 16, 1899	146.05	April 16, 1899	1.5
1899–1900	141.25	June 27, 1900	145.98	December 27, 1899	4.73

THE CONDUIT AND CONDUIT ROAD.

Gutters, ditches, culverts, and drains were repaired and cleaned; a dry stone wing-wall was constructed at culvert No. 12, 41 cubic yards of stone being used; 4 small road culverts were constructed, and the road was repaired. Eight thousand one hundred and eighty-eight linear feet of road fence were constructed and all fences were whitewashed.

The conduit between the Great Falls and the Dalecarlia Reservoir was emptied three times—the first time in August, 1899, for the purpose of cleaning, when 143 cubic yards of deposit were removed; the second time in January, 1900, for the purpose of repairing leaks in Cabin John Bridge, which was done by coating the inside of the conduit with Portland cement; the third time in June, 1900, for the purpose of cleaning, when 85 cubic yards of deposit were removed. The conduit between the two reservoirs was emptied in August for the purpose of cleaning, when 5 cubic yards of deposit were removed.

Preparations for the repair of the by-conduit around the Dalecarlia Reservoir were made.

The by-conduit around the distributing reservoir was emptied in April for cleaning, when a small deposit of a few inches was removed by flushing. This conduit was again emptied in March on account of the construction of the new gatehouse at the west shaft.

Four hundred and thirty-four cubic yards of mud were removed from the canal outside of wasteweir No. 1. A new walk in the tunnel leading to wasteweir No. 2 was constructed.

THE BRIDGES.

A new floor was put on the bridge across the spillway at the Dalecarlia Reservoir, and the construction of a new floor on the Pennsylvania Avenue Bridge across Rock Creek was begun and about half completed.

The Pennsylvania Avenue Bridge and the College Pond Bridge were painted. All the bridges are now in excellent condition.

The roadway of Pennsylvania avenue, which in the vicinity is 53.5 feet in clear width, is contracted on the bridge to a clear width of but 17 feet, and as drivers are required to walk their teams while passing over the bridge, a congestion of travel results during the busiest hours of the day, causing delay and annoyance, as there is not room for one

team to pass another, and consequently the speed of all teams on the bridge moving in the same direction is limited by that of the team in front. Especially is this annoyance felt by the thousands of bicycle riders who daily pass over the bridge and who, unless experienced riders, are frequently forced to dismount and lead their bicycles over the bridge, the rate of progress of the teams blocking the roadway ahead being too slow to allow an inexperienced rider to maintain equilibrium. In addition, the sightly appearance of the avenue is much injured by the extreme contraction at this point.

This bridge, the property of the Washington Aqueduct, is very graceful in appearance and is unique among the bridges of the world, in that the roadway is supported upon arched ribs formed by two 48-inch cast-iron pipes, through which flows at least half of the water consumed by the city. It would seem, therefore, that any plan to widen the bridge should preserve both the graceful form and the distinctive features of the bridge.

A board of engineers, constituted by Special Orders, No. 8, February 2, 1877, and composed of the following officers of the United States Corps of Engineers, Bvt. Maj. Gen. Z. B. Tower, Bvt. Maj. Gen. H. G. Wright, and Bvt. Maj. Gen. Q. A. Gillmore, was assembled to examine into the propriety of certain proposed modifications of this bridge. This board, after due consideration of the matter, reported as follows:

> It would, in our opinion, therefore, better accord with the position on Pennsylvania avenue and with the general character and architectural effect of other aqueduct structures to widen this structure, without changing its design, by the addition of two arched iron ribs similar to those of the present bridge and by widening the abutments.
>
> These two arched ribs should be made about as heavy as those of the present bridge. As the previous discussion shows the latter to be abundantly strong without the truss work, in the new construction the greater portion of the whole weight of the bridge could be thrown upon the added arches not used as water pipes.
>
> We regard the arch as far more sightly, beautiful, and architectural than the truss, and therefore more suitable for this position.

On April 26, 1877, the late Gen. Thomas L. Casey, United States Corps of Engineers (retired), then in charge of the Washington Aqueduct, was requested by the Chief of Engineers to investigate and report upon "the present and prospective use of that bridge as a highway, etc." This he did on July 19, 1877, his report concluding with the following opinion:

> I am further of opinion that the present and prospective interests of the citizens of Washington and Georgetown do demand an increase in the width of the roadway and of the footways, the present width being, of the roadway only 17 feet, and of the footways 4½ feet each.
>
> The abundant strength and stiffness of the present bridge, under any statical or moving loads that are likely to be placed upon it, are clearly shown by the investigations of the board of engineers, as detailed in its report of April 7, 1877, and I agree with it as to the manner in which the widening of the road and foot ways should be accomplished, should it be decided to increase their width, namely, by the addition of two arched iron ribs, similar to those of the present bridge, and by widening the abutments. The estimated cost of widening the bridge in the manner above stated is $75,000.

While it is believed that the interest and convenience of the citizens of Washington and Georgetown demand the widening of this bridge, yet because the present structure amply suffices for all requirements of the Washington Aqueduct system, and because during the past few

years no official complaints regarding the width of the bridge have been made to this office, no estimate is submitted for this work, the estimates for the next fiscal year being confined to those subjects directly affecting the operation of the Washington Aqueduct.

THE MAINS.

The trunk mains, aggregating 21 miles in length, which lead from the distributing reservoir and supply the distributing system of street mains, were laid by the United States and are under the control of this office, but the distributing mains were laid by the city of Washington and the District of Columbia, and are under the care and control of the Commissioners of the District.

A break in the 12-inch main 100 feet west of College Pond was repaired by putting in new 5-foot sections of pipe.

The 48-inch main at Fourth and Q streets NW. was lowered from 1 to 13 inches for a distance of 288 feet, and the 48-inch main at Fourth and Elm streets NW. was lowered from 1 to 9 inches for a distance of 228 feet. These mains were lowered so as to allow the construction of an electric railway, and the expense of lowering the mains was borne by the railroad company.

THE TELEPHONE LINE.

Small repairs were made to the telephone line during the year.

CONSUMPTION AND WASTE OF WATER.

Measurements of the daily and hourly consumption and waste of water were made on June 26–27, 1900, and a detailed record of the measurements is given in the following table:

Measurements of the daily and hourly consumption and waste of water.

[Hourly and total flow from the distributing reservoir for twenty-four hours ending at 7 a. m.]

Hours.	Outflow per hour June 26-27, 1900.	Remarks.
	Gallons.	
7 a. m. to 8 a. m	2,392,368	City temperature in the shade at 2 p. m., June 26, 91° F. Weather clear.
8 a. m. to 9 a. m	1,967,447	
9 a. m. to 10 a. m	2,105,452	
10 a. m. to 11 a. m	2,102,664	
11 a. m. to 12 noon	1,960,055	
12 noon to 1 p. m	1,957,753	
1 p. m. to 2 p. m	2,094,786	
2 p. m. to 3 p. m	2,092,243	
3 p. m. to 4 p. m	2,089,333	
4 p. m. to 5 p. m	1,669,625	
4 p. m. to 5 p. m., rainfall	351,777	
5 p. m. to 6 p. m	2,362,190	
5 p. m. to 6 p. m., rainfall	222,792	
6 p. m. to 7 p. m	2,220,188	
7 p. m. to 8 p. m	1,939,937	
8 p. m. to 9 p. m	2,076,123	
9 p. m. to 10 p. m	2,349,344	
10 p. m. to 11 p. m	2,208,069	
11 p. m. to 12 midnight	2,205,038	
12 midnight to 1 a. m	2,201,176	
1 a. m. to 2 a. m	1,786,994	
2 a. m. to 3 a. m	2,058,825	
3 a. m. to 4 a. m	2,056,370	
4 a. m. to 5 a. m	2,190,373	
5 a. m. to 6 a. m	1,914,122	
6 a. m. to 7 a. m	2,231,593	
Total	50,897,227	

Measurements of the daily and hourly consumption of water were made each month, and the amounts are given in the following table:

		Gallons.
1899.	July 26–27	46,596,825
	August 24–25	50,149,905
	September 27–28	47,752,932
	October 25–26	46,437,485
	November 28–29	43,855,243
	December 29–30	58,102,486
1900.	January 24–25	47,424,837
	February 23–24	50,423,237
	March 27–28	47,085,452
	April 26–27	45,145,490
	May 24–25	47,831,560
	June 26–27	50,897,227

or a daily average of twelve measurements of consumption and waste for the fiscal year of 48,459,977 gallons.

The following table gives the daily consumption of water by the District of Columbia as furnished by the Washington Aqueduct:

Date.	Daily consumption.	Population.	Amount per capita per diem.
	Gallons.		*Gallons.*
1874	17,554,848	*a* 130,182	134
1875	21,000,000	*a* 138,091	152
1876	24,177,797	*a* 146,000	165
1877	23,252,932	*a* 153,909	151
1878	24,885,945	*a* 161,818	154
1879	25,947,642	*a* 169,727	153
1880	25,740,138	*b* 177,638	145
1881	26,525,991	*a* 182,893	145
1882	29,727,864	*a* 187,968	158
1883	24,314,715	*a* 193,133	126
1884	24,827,113	*a* 198,198	125
1885	25,219,194	*c* 203,459	124
1886	25,542,476	*a* 208,358	123
1887	26,878,424	*a* 213,357	126
1888	29,115,774	*a* 218,157	133
1889	27,708,779	*a* 225,309	123
1890	35,541,845	*b* 232,460	153
1891	38,594,743	*a* 248,539	155
1892	41,161,780	*c* 264,618	156
1893	46,727,108	*a* 267,569	171
1894	49,162,357	*c* 270,519	182
1895	47,182,681	*a* 272,677	173
1896	44,113,574	*a* 274,815	161
1897	45,467,047	*c* 276,963	163
1898	47,288,733	*a* 277,548	170
1899	50,079,855	*a* 278,133	180
1900	50,897,227	*b* 278,718	183

a Estimated. *b* United States census. *c* Police census.

From the above it will be observed that the consumption and waste of water in the District of Columbia for June 27, 1900, was 50,897,227 gallons per diem. This is the largest June measurement ever taken. The United States census of 1900 gives the population of the District of Columbia as 278,718, which gives a daily per capita consumption and waste of 183 gallons.

Careful and trustworthy investigations and measurements made in various cities in the United States show clearly that a per capita daily consumption of 100 gallons is ample for all domestic, business, and public purposes, and that any considerable increase above this amount must be attributed to waste, due to defective mains and service pipes, defective plumbing, and willful waste.

This extravagant use of water has become a serious menace to the supply of water by the Washington Aqueduct with its present capacity. The capacity of the aqueduct, with a head of 146 feet at the distributing reservoir, a head necessary to keep up the present pressure for the gravity supply, is 50,000,000 gallons per diem. If the level of the distributing reservoir were lowered to 144 feet, the ultimate safe limit of supply is 76,000,000 gallons. This latter involves a loss of head of 2 feet, so that to obtain the same pressure with the supply additional pumping would be required.

The present consumption and waste has also an important bearing on the subject of filtration.

A report on the subject of filtering the water supply of Washington was called for by Congress and submitted by this office on March 28, 1900. (See Senate Document No. 259, Fifty-sixth Congress, first session.) It is probable that the cost of filtration will be about $6 per million gallons, or, at the present rate of consumption, about $300 per day, or $110,000 annually. This is a large charge and can only be reduced by a reduction in consumption.

The existing conditions suggest two remedies—either the reduction of consumption to a reasonable rate, 100 gallons per capita per diem, or the increase of the present supply to keep up with the present unreasonable and extravagant demand of 183 gallons per capita per diem.

The first remedy, the reduction of consumption, can only be accomplished by the introduction of meters. This is a positive and certain method and has been shown by actual experience to be perfectly feasible. However, whenever this subject of the introduction of meters has been brought to the attention of Congress it has failed to meet approval.

Capt. Edward Burr, Corps of Engineers, U. S. A., when in charge of the water department of the District of Columbia, made an able and exhaustive report on this subject. (See Report of the Commissioners of the District of Columbia for the fiscal year ending June 30, 1897, Vol. II, p. 181 et seq.)

Captain Burr says (p. 189–191):

A résumé of the above figures as to per capita use of water is—

	Gallons.
For domestic purposes, 27, or, say	30
For commercial and United States purposes, 27, or, say	30
For sprinkling (maximum), 12, or, say	15
Total maximum legitimate use	75

Add for waste, not deliberate or willful, 25 gallons, and the total is 100 gallons per capita, or 28,000,000 gallons a day. With such an allowance and supply of water there would be ample for all purposes—domestic, commercial, and public. There would be no necessity for stinting or economy in any legitimate use of water. All that is necessary is the suppression of careless, deliberate, and willful waste, due to defective plumbing, known or unknown, and positive personal violations of regulations in opening fixtures to allow water to run continuously.

There is but one means to fully control and suppress such waste—the general extension of the meter system to all classes of consumers, domestic as well as commercial. Until this means is adopted periodical shortages in the water supply of this city must be expected, not because the supply of water is insufficient for all legitimate uses, but because 70 per cent of it is wasted and serves no good end whatever.

That the general introduction of meters will accomplish this end without hardship, increased cost to consumers, insanitary conditions, or any curtailment of the proper

use of water, there can be no doubt. The opinion of all authorities and the experience of all communities where the meter system has been generally introduced lead to this belief. By the use of meters is obtained a suppression of waste, a uniformity of water rates according to the amount of water used or wasted, and an increase of pressure, with a general improvement of the service without the expenditure of large sums for enlargements of works.

To illustrate the benefits of the meter system it is necessary to refer to but one city, Detroit, with about the same population as the District of Columbia. The following quotations are taken from a statement made by Mr. L. N. Case, superintendent of the Detroit waterworks, before a committee of the legislature of the State of Michigan, having under consideration what is known as the "free-water bill" for Detroit:

"There has been found but one really efficient restriction to waste, and that is the meter, although assessing upon the basis of consumption as estimated is partially so. * * *

"For years, and up to 1889, Detroit, Buffalo, and Philadelphia operated upon the assessment plan entirely. Detroit pumped a daily per capita supply of 204 gallons. Our capacity was more than exhausted, and complaints of short supplies were bitter and increasing. March 6, 1889, I demonstrated to the board that meters must be used to stop this enormous waste or an enlargement of the works entered into immediately at an estimated expense of $600,000.

"The introduction of meters was decided upon. The following conditions of the three cities in 1887 and 1896 will show the results of the introduction of meters in Detroit and the continuance of the old method in Buffalo and Philadelphia:

Daily pumpage, in million gallons.

	Buffalo.	Philadelphia.	Detroit.
1887	38	88	36
1896	101	239	36
Increase in population.....per cent..	34	46	56

"Detroit, at the same rate of increase of Buffalo and Philadelphia, which corresponded exactly with her increase previous to using meters, would have pumped 101,000,000 gallons daily. This would have required an expenditure of over $200,000 for engines and pipes more than was expended, and an extra expense for pumping water of $94,900 for last year, with a proportionate increase for the intervening years."

* * * * * * *

One-third increased pressures!

The result in Detroit is a stationary total consumption for ten years, with a 56 per cent increase in population and a per capita decrease from 203 to 130 gallons. This was accomplished by metering about 5,000 consumers of a total of 49,000, and while the effect is marked the per capita supply still shows large waste, that can be reduced by increasing the number of meters.

In this city (Washington) the increase in the use of meters has produced a similar but no less marked effect. The existing law requires the use of meters only by hotels, livery stables, manufacturing establishments, and other large consumers. Since 1894 all such consumers have been required to use meters. The following table shows the result:

	1894.	1895.	1896.	1897.
Number of premises supplied	44,185	45,675	46,908	48,540
Number of meters	202	231	574	777
Water supplied.....gallons..	49,162,000	47,182,000	44,114,000	45,267,000
Per capita.....do....	181	173	165	164

With an increase since 1894 of 4,355 in the number of premises supplied with water, the total daily supply is reduced by about 4,000,000 gallons and the per capita supply from 181 to 164 gallons.

This can be attributed to no other cause than to the metering of about 500 large consumers of the character mentioned above.

The introduction of meters will not prevent an abundant supply for all purposes, will result in a less water rate or expense to consumers, and would throw the burden of waste where it belongs, on the shoulders of the careless and willfully negligent consumers.

The second remedy is an increase of the water supply to meet future demands at the present extravagant rate of consumption.

This involves the building of a second conduit from the Great Falls of the Potomac, with the necessary reservoirs, if any, and proper gate houses and operating plant. In order that this subject may have proper consideration, with due deliberation and prevision, a survey of practicable routes is essential. These surveys should be taken in hand at once, and an estimate for such surveys is submitted with this report.

REPAIRING THE NORTH CONNECTION OF THE BY-CONDUIT.

The amount appropriated by act of March 3, 1899, for repairing the north connection of the by-conduit at the Dalecarlia Reservoir was expended in the purchase of materials and machinery necessary in the prosecution of this work. The amount, $10,000, appropriated by act of June 6, 1900, for this purpose will be sufficient to complete the work and no additional estimate is made.

STOREHOUSE AND STABLE AT GREAT FALLS.

A suitable storehouse and stable should be erected at Great Falls for the storage of tools and implements belonging to the United States, and the stabling of the watchman's horses, which are a necessity to him for the proper performance of his duties. For this an estimate of $3,000 is submitted.

On June 11, 1900, Thomas Sullivan, watchman and gatekeeper at Great Falls, died.

Sullivan had been in the employ of the Washington Aqueduct since 1857. From 1861 to 1865 he served in the Union Army and returned to the work in 1865, when he was appointed watchman and gatekeeper at Great Falls. He was a faithful, diligent, and upright servant of the Government.

ESTIMATES.

The estimates of appropriations which should be made for the year ending June 30, 1902, are as follows:

For building combined storehouse and stable at Great Falls	$3,000
For preliminary surveys for additional conduit from Great Falls	8,000
For operation, maintenance, repair, etc., of the aqueduct and its accessories, including the Conduit road	25,000
Total	36,000

Money statements.

WASHINGTON AQUEDUCT

Amount appropriated by act of March 3, 1899	$21,000.00
June 30, 1900, amount expended during fiscal year	18,914.73
July 1, 1900, balance unexpended	2,085.27
July 1, 1900, outstanding liabilities	2,085.27
Amount that can be profitably expended in fiscal year ending June 30, 1902	36,000.00

WASHINGTON AQUEDUCT, D. C., 1900: REPAIRING CONDUIT ROAD.

Amount appropriated by act of March 3, 1899	$1,000.00
June 30, 1900, amount expended during fiscal year	910.66
July 1, 1900, balance unexpended	89.34
July 1, 1900, outstanding liabilities	89.34

WASHINGTON AQUEDUCT, D. C., 1900: REPAIRING NORTH CONNECTION OF BY-CONDUIT.

Amount appropriated by act of March 3, 1899	$3,000.00
June 30, 1900, amount expended during fiscal year	2,240.00
July 1, 1900, balance unexpended	760.00
July 1, 1900, outstanding liabilities	760.00

Appropriations made for the Washington Aqueduct, with the dates of acts for the same.

Date.	Amount.	Date.	Amount.	Date.	Amount.
September 30, 1850	$500	June 10, 1872	$70,555	March 3, 1887	$20,000
August 31, 1852 *a*	5,000	January 23, 1873	14,000	July 18, 1888 *h*	20,000
March 3, 1853	100,000	March 3, 1873 *c*	43,600	March 2, 1889 *i*	20,000
March 3, 1855	250,000	June 23, 1874 *d*	36,400	August 6, 1890 *j*	25,500
August 18, 1856	250,000	March 3, 1875	26,000	March 3, 1891 *k*	20,000
March 3, 1857	1,000,000	July 31, 1876	22,000	July 14, 1892	20,000
June 12, 1858	800,000	March 3, 1877	15,000	March 3, 1893	80,000
June 25, 1860	500,000	June 20, 1878	15,000	August 7, 1894 *m*	82,500
July 4, 1864	150,000	March 3, 1879 *e*	20,000	March 2, 1895 *n*	71,500
July 28, 1866	142,584	June 4, 1880 *f*	20,000	June 11, 1896 *o*	25,000
December 20, 1866	12,000	March 3, 1881	20,000	March 3, 1897 *p*	26,000
March 2, 1867	20,000	July 1, 1882 *g*	20,000	June 30, 1898	22,000
July 25, 1868	52,500	March 3, 1883	20,000	March 3, 1899	25,000
March 3, 1869	25,000	July 5, 1884	20,000		
July 15, 1870 *b*	120,822	February 25, 1885	20,000	Total	4,402,657
March 3, 1871	114,196	July 9, 1886	20,000		

NOTE.—Reverted to the Treasury: (*a*) $2.81, (*b*) $46.25, (*c*) $560.87, (*d*) 35 cents, (*e*) $1,109.87, (*f*) $381.06, (*g*) $1,354.17, (*h*) $2,266.34, (*i*) $4.12, (*j*) $5,500, (*k*) $2.49, (*m*) $39.96, (*n*) $2,983.87, (*o*) $285.85, (*p*) $1,828.53, $4.38 from regular appropriation for Washington Aqueduct, and $1,824.15 from appropriation for constructing telephone line; total, $16,366.54. Since 1878 one-half of the amounts appropriated has been contributed by the United States and the other half by the District of Columbia.

APPENDIX 1.

CONDITION OF THE WATER DURING THE YEAR.

Condition of the water at Great Falls, Dalecarlia Reservoir, and distributing reservoir, and height of water over the dam at Great Falls for each day during the year.

Day of month.	Condition of water.			Height of water over dam at Great Falls (feet).	Condition of water.			Height of water over dam at Great Falls (feet).	Condition of water.			Height of water over dam at Great Falls (feet).	Condition of water.			Height of water over dam at Great Falls (feet).
	Great Falls.	Dalecarlia receiving reservoir, south connection.	Distributing reservoir, effluent gatehouse.		Great Falls.	Dalecarlia receiving reservoir, south connection.	Distributing reservoir, effluent gatehouse.		Great Falls.	Dalecarlia receiving reservoir, south connection.	Distributing reservoir, effluent gatehouse.		Great Falls.	Dalecarlia receiving reservoir, south connection.	Distributing reservoir, effluent gatehouse.	
	July, 1899.				August, 1899.				September, 1899.				October, 1899.			
1	36	36	36	0.70	36	36	36	0.50	7	3	28	0.80	7	4	14	0.70
2	36	36	36	.70	36	36	36	.50	9	4	11	.70	9	6	15	.70
3	36	36	36	.70	8	36	36	.50	6	17	20	.70	13	6	16	.70
4	36	36	36	.70	10	36	36	.50	13	20	22	.80	19	9	18	.70
5	36	36	36	.70	18	24	36	.50	6	16	23	.80	22	12	20	.70
6	1	36	36	.70	10	30	36	.60	14	20	23	.70	15	21	21	.70
7	4	22	36	.70	12	36	36	.60	26	28	36	.70	27	20	27	.70
8	34	11	36	.70	23	36	36	.60	29	36	36	.60	27	27	27	.70
9	2	17	30	.70	26	36	36	(a)	36	36	36	.60	28	31	30	.80
10	23	10	26	.70	28	26	36	.60	33	36	36	.60	29	36	36	.80
11	36	9	24	.70	36	7	36	.60	30	35	36	.60	29	36	36	.80
12	36	22	26	.70	36	22	30	.90	34	36	36	.60	29	36	36	.80
13	36	36	36	.70	13	36	36	.60	34	36	36	.70	30	36	36	.80
14	36	36	36	.70	32	36	36	.60	36	36	36	.80	33	36	36	.80
15	25	36	36	.70	16	36	32	.60	36	36	36	.80	36	36	36	.80
16	36	30	36	.70	10	36	36	.60	28	36	36	.80	36	36	36	.80
17	1	36	36	.80	20	30	36	.60	36	36	36	.80	36	36	36	.70
18	4	15	36	.80	27	22	36	.60	36	36	36	.80	36	36	36	.70
19	2	9	36	.70	34	36	36	.60	36	36	36	.80	36	36	36	.70
20	5	4	33	.70	36	36	36	.60	25	36	36	.80	36	36	36	.70
21	18	4	30	.60	36	36	36	.60	16	36	36	.90	36	36	36	.70
22	30	9	28	.60	36	36	36	.60	24	36	36	.80	36	36	36	.70
23	36	30	24	.60	36	36	36	.60	9	30	36	.80	36	36	36	.70
24	36	36	27	.60	36	36	36	.60	7	27	36	.80	36	36	36	.70
25	36	36	33	.60	36	36	36	.60	5	24	36	.80	36	36	36	.70
26	36	36	36	.60	36	36	36	.50	1	14	36	1.00	36	36	36	.70
27	36	36	36	.60	36	36	36	.50	2	6	36	1.00	36	36	36	.70
28	36	36	36	.60	32	36	36	.80	3	4	36	.90	36	36	36	.70
29	36	36	36	.60	1	36	36	.50	4	3	23	.70	36	36	36	.70
30	36	36	36	.60	2	19	36	.90	5	3	18	.70	36	36	36	.70
31	36	36	36	.50	3	4	36	.90	....	......	......	......	36	36	36	.70

a Water shut off; cleaning conduit.

Condition of the water at Great Falls, Dalecarlia Reservoir, and distributing reservoir, and height of water over the dam at Great Falls for each day during the year—Continued.

Day of month.	Condition of water.			Height of water over dam at Great Falls (feet).	Condition of water.			Height of water over dam at Great Falls (feet).	Condition of water.			Height of water over dam at Great Falls (feet).	Condition of water.			Height of water over dam at Great Falls (feet).
	Great Falls.	Dalecarlia receiving reservoir, south connection.	Distributing reservoir, effluent gatehouse.		Great Falls.	Dalecarlia receiving reservoir, south connection.	Distributing reservoir, effluent gatehouse.		Great Falls.	Dalecarlia receiving reservoir, south connection.	Distributing reservoir, effluent gatehouse.		Great Falls.	Dalecarlia receiving reservoir, south connection.	Distributing reservoir, effluent gatehouse.	
	November, 1899.				December, 1899.				January, 1900.				February, 1900.			
1	18	36	36	0.80	36	36	36	0.80	6	4	3	0.70	12	12	6	0.70
2	5	36	36	1.10	36	36	36	.80	6	6	4	.90	18	13	7	.80
3	3	20	36	1.20	36	36	36	.80	6	7	4	.90	30	20	8	.80
4	3	15	36	1.40	36	36	36	.80	11	7	5	.80	30	25	10	.90
5	4	6	36	1.30	36	36	36	.80	12	8	6	.80	10	30	13	1.00
6	5	3	36	1.20	36	36	36	.80	12	6	7	.80	18	29	16	1.00
7	7	6	36	1.10	36	36	36	.80	12	7	7	.80	16	18	23	1.00
8	8	8	36	1.10	36	36	36	.80	27	10	9	.70	28	22	21	1.10
9	10	12	36	1.00	36	36	36	.80	29	15	10	.80	2	20	23	1.20
10	22	20	36	.90	36	36	36	.80	32	22	12	.80	3	8	27	1.30
11	24	24	36	.90	36	36	36	.80	34	30	15	.70	1	4	22	1.50
12	28	30	36	.90	36	36	36	.80	3	36	21	.80	1	3	14	1.50
13	30	33	36	.90	36	36	36	.80	3	36	35	.90	1	1	8	1.50
14	36	36	36	.90	36	36	36	.80	3	7	30	.80	1	2	8	2.00
15	36	36	36	.80	20	36	36	1.40	3	4	25	(*a*)	1	2	3	2.20
16	36	36	36	.80	8	36	36	1.40	3	5	20	(*a*)	1	1	3	1.30
17	36	36	36	.80	10	36	36	1.20	4	5	11	1.00	1	1	2	2.00
18	36	36	36	.80	12	31	36	1.20	5	3	6	1.00	1	1	2	1.70
19	36	36	36	.80	11	20	36	1.10	6	4	7	1.30	1	1	2	1.50
20	36	36	36	.80	8	23	36	1.10	6	7	9	1.30	2	2	2	1.50
21	36	36	36	.70	7	24	36	1.00	1	8	10	1.70	5	2	2	1.40
22	36	36	36	.70	9	18	36	1.00	1	6	10	1.70	1	4	2	2.00
23	36	36	36	.70	5	12	36	.90	1	6	6	2.50	1	5	2	2.50
24	36	36	36	.70	5	8	32	1.00	1	2	5	2.00	1	2	3	2.70
25	36	36	36	.70	2	6	31	1.20	1	3	4	1.70	1	1	2	2.50
26	36	36	36	.70	1	3	27	1.40	1	2	3	1.60	1	1	2	2.00
27	36	36	36	.70	1	3	27	1.30	2	2	3	1.50	2	2	2	1.60
28	36	36	36	.80	1	2	15	1.20	3	2	3	1.50	3	4	2	1.60
29	36	36	36	.80	2	3	5	.80	3	4	3	1.30	....	......	......	......
30	36	36	36	.80	4	3	2	.70	7	6	4	.90	....	......	......	......
31	....	......	......	......	6	3	2	.70	10	8	5	.80	....	......	......	......

a Water shut off; repairing leak in Cabin John Bridge.

Condition of the water at Great Falls, Dalecarlia Reservoir, and distributing reservoir, and height of water over the dam at Great Falls for each day during the year—Continued.

Day of month.	March, 1900. Condition of water. Great Falls.	March, 1900. Condition of water. Dalecarlia receiving reservoir, south connection.	March, 1900. Condition of water. Distributing reservoir, effluent gatehouse.	March, 1900. Height of water over dam at Great Falls (feet).	April, 1900. Condition of water. Great Falls.	April, 1900. Condition of water. Dalecarlia receiving reservoir, south connection.	April, 1900. Condition of water. Distributing reservoir, effluent gatehouse.	April, 1900. Height of water over dam at Great Falls (feet).	May, 1900. Condition of water. Great Falls.	May, 1900. Condition of water. Dalecarlia receiving reservoir, south connection.	May, 1900. Condition of water. Distributing reservoir, effluent gatehouse.	May, 1900. Height of water over dam at Great Falls (feet).	June, 1900. Condition of water. Great Falls.	June, 1900. Condition of water. Dalecarlia receiving reservoir, south connection.	June, 1900. Condition of water. Distributing reservoir, effluent gatehouse.	June, 1900. Height of water over dam at Great Falls (feet).
1	2	4	2	1.60	8	15	11	1.70	36	36	36	1.20	22	36	30	0.90
2	1	3	3	2.10	16	12	15	1.80	36	36	36	1.20	32	36	32	.90
3	1	22	3	2.50	11	21	20	1.70	36	36	36	1.10	29	36	30	1.00
4	1	2	3	2.50	11	25	23	1.60	36	36	36	1.10	31	36	30	1.00
5	1	1	2	2.10	13	20	32	1.60	36	36	36	1.10	28	36	32	1.00
6	3	1	2	1.90	13	25	31	1.70	36	36	36	1.10	29	28	33	1.00
7	3	2	2	1.80	11	23	36	1.40	36	36	36	1.10	33	28	36	1.00
8	3	4	2	1.80	22	27	36	1.40	36	36	36	1.00	36	36	36	.90
9	3	3	2	1.90	25	28	36	1.30	36	36	36	1.00	36	36	36	(*a*)
10	4	2	3	1.80	28	36	36	1.30	36	36	36	1.00	34	36	36	.80
11	6	4	3	1.70	30	36	36	1.30	36	36	36	1.00	31	36	30	.80
12	8	6	3	1.70	29	36	36	1.30	36	36	36	1.00	36	36	36	.80
13	9	6	4	1.60	32	36	36	.70	36	36	36	1.00	36	36	29	.80
14	10	7	4	1.50	30	36	36	1.20	36	36	36	.90	36	36	30	.80
15	10	9	5	1.60	31	36	36	1.20	36	36	36	.90	1	36	30	.80
16	17	11	7	1.40	35	36	36	1.20	36	36	36	.90	6	8	26	.80
17	11	15	7	1.40	36	36	36	1.20	36	36	36	.90	1	3	16	1.00
18	14	18	11	1.40	36	36	36	1.20	36	36	36	.90	3	2	11	1.40
19	18	24	16	1.40	11	36	36	1.20	36	36	36	.90	1	2	11	2.80
20	2	1	16	1.60	27	36	36	1.20	10	36	36	.90	1	6	9	1.40
21	1	20	24	2.10	33	36	36	1.20	8	36	36	1.10	2	3	12	2.00
22	1	12	25	3.30	29	30	36	1.20	7	24	36	1.10	3	2	14	1.60
23	1	6	17	2.80	29	36	36	1.30	8	20	36	1.10	3	4	14	1.40
24	2	3	14	1.30	21	36	36	1.30	10	17	36	1.00	5	7	14	1.30
25	3	2	7	2.00	28	36	26	1.30	20	9	30	1.00	8	8	21	1.40
26	6	3	6	1.90	23	36	36	1.30	20	13	28	1.00	13	5	25	1.00
27	8	5	5	1.30	33	36	36	1.30	26	28	28	1.00	26	10	26	1.00
28	12	7	6	1.70	33	36	36	1.30	27	28	25	.90	21	34	25	1.00
29	12	7	6	1.70	35	36	36	1.20	26	23	20	.90	34	28	28	1.00
30	16	9	7	1.70	36	36	36	1.20	30	29	25	.90	36	36	30	.90
31	14	12	9	1.60	....	......	......	......	30	32	30	.90	....	......	......	......

a Water shut off; cleaning conduit.

According to the scale for recording the condition of the water as regards clearness, the numbers 0 to 7, inclusive, correspond to very turbid; 8 to 14, turbid; 15 to 21, slightly turbid, and 22 to 36, clear. The following table shows the condition of the water at various parts of the system during the year:

Condition.	Number of days when this condition existed at— Great Falls.	Number of days when this condition existed at— Dalecarlia Reservoir, effluent gatehouse.	Number of days when this condition existed at— Distributing reservoir, effluent gatehouse.
Very turbid	108	92	61
Turbid	50	31	25
Slightly turbid	20	27	20
Clear	187	215	259
Total	365	365	365

Daily gauge pressures at the office of the Washington Aqueduct at 9 o'clock a. m.

Month.	Main.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.	Average.
1899.	*Inch.*																																
	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
July	36	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31
	48	34	35	34	34	34	34	34	34	34	34	34	35	34	34	35	34	34	35	35	35	34	35	35	35	35	34	34	34	35	35	35	34.42
	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
August	36	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31
	48	34	34	35	35	34	34	34	34	34	34	34	34	34	34	33	33	35	34	35	35	35	35	35	34	34	34	34	34	34	34	35	34.70
	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	....	30
September	36	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	....	31
	48	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	....	35
	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
October	36	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31
	48	35	35	35	35	35	35	35	35	35	35	35	35	34	34	34	34	35	34	34	34	34	34	35	34	34	34	34	34	34	34	34	34.45
	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	....	30
November	36	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	....	31
	48	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	....	35
	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
December	36	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31
	48	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	34	34	33	33	34.83
1900.																																	
	30	(a)	(a)	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
January	36	30	30	30	30	30	30	30	30	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	30.74
	48	32	32	32	32	33	34	35	35	35	35	35	35	35	35	35	35	35	35	35	36	35	35	36	35	35	35	35	35	35	34	34	34.55
	30	28	28	28	28	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	(a)	30	....	....	....	29.70
February	36	30	30	30	30	30	30	30	30	31	31	31	31	31	31	31	31	31	30	30	31	31	31	31	31	31	30	30	31	....	....	....	30.57
	48	33	33	33	33	33	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	34	34	35	....	....	....	34.57
	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
March	36	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31
	48	35	35	35	35	35	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	36	35.84
	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	....	30
April	36	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	....	31
	48	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	36	36	35	....	36.87
	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
May	36	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31
	48	35	35	35	35	35	35	35	35	35	35	35	35	36	36	36	36	36	37	37	37	37	37	37	37	37	37	37	37	37	37	37	36.06
	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	....	30
June	36	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	....	31
	48	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	....	37

a Gauge pipe frozen.

G G G 2.

INCREASING THE WATER SUPPLY OF WASHINGTON, DISTRICT OF COLUMBIA.

This work is being prosecuted under an act making appropriations to provide for the expenses of the government of the District of Columbia for the fiscal year ending June 30, 1899, and for other purposes, approved June 30, 1898.

The clause of this act making appropriations for this work is as follows:

Washington Aqueduct Tunnel: The Secretary of War is hereby authorized and directed to resume work on the Washington Aqueduct Tunnel and its accessories and the Howard University Reservoir, authorized by section two of the act approved July fifteenth, eighteen hundred and eighty-two, entitled "An act to increase the water supply of the city of Washington, and for other purposes," and to prosecute and complete the same; the work on the said tunnel and accessories to be carried on in accordance with the plans of the board of experts as set forth in its report dated January seventeenth, eighteen hundred and ninety-six, House Document numbered one hundred and sixty-six, Fifty-fourth Congress, first session, which plans have been approved by the Chief of Engineers and the Secretary of War. And to carry out the provisions of said act and this paragraph, the balance remaining unexpended from the appropriations made by the said act of July fifteenth, eighteen hundred and eighty-two, and by subsequent acts for said purpose, amounting to two hundred and ninety-seven thousand two hundred and ten dollars and fifty cents, is hereby reappropriated, to be advanced out of the revenues of the United States, and not subject to the conditions of the capital account created by the act of July fifteenth, eighteen hundred and eighty-two, and the sum of two hundred and ninety-seven thousand two hundred and ten dollars and fifty cents is also hereby appropriated out of the surplus general revenues of the District of Columbia, to be applied to such parts of the work and in such order as to time as the Secretary of War may deem necessary to promote as soon as practicable the completion of the entire system of said works: *Provided*, That the sums herein set apart and appropriated shall be immediately available and shall be expended under the direction of the Secretary of War and the supervision of the Chief of Engineers; and the work shall be carried on by contract or otherwise, as the Secretary of War may deem best for the public interest.

The work is to be carried on, in compliance with the above act, "in accordance with the plans of the Board of experts as set forth in its report, dated January 17, 1896."

That portion of the report referred to which contains the plans of the Board of experts is as follows:

PERCOLATION.

One of the objections against the tunnel that has been urged with much force is the liability of leakage or percolation outward from the tunnel into the ground when it is subjected to the pressure of the water. This is a point to which we have devoted much time and attention. It is evident that should the leakage be sufficiently great the dangers to be apprehended from this source might be considerable. These possible dangers, however, are materially lessened by a consideration of the fact that from all the information we have been able to collect, it appears that for a considerable portion of the tunnel the natural level of the water in the ground is not far different from that of the hydraulic grade line of the water in the tunnel.

Since this tunnel was abandoned the new Croton Aqueduct, supplying the city of New York with water, has been completed. A portion of this aqueduct, embracing a length of about 7 miles, is subjected to internal pressure with a maximum pressure due to a head of about 130 feet. In this case no serious percolation has been observed, although the surface of the ground is at several points much below the hydraulic grade line. An experiment made for the purpose of determining the amount of this leakage outward from the aqueduct showed that the total loss in the whole 7 miles from this cause did not exceed 225,000 gallons in twenty-four hours.

With this practical example before the commission, and guided by our own judgment and experience, we believe that if the spaces now existing between the brick-

work and the rock are thoroughly filled with rubble masonry and grouted, that the tunnel can be made sufficiently watertight, and that the leakage under a head of 150 feet will not be large enough to prove an obstacle in the way of the successful completion and operation of the tunnel. In this connection we recommend that the interior surface of the whole tunnel should receive a double coating or wash of pure Portland cement. This treatment will aid materially in making the brickwork more impervious to the passage of water.

Objection has also been urged against the tunnel on the ground of the danger of contamination to the supply from the percolation of ground water into the tunnel when it is empty. This condition can occur but seldom, perhaps but once or twice a year at the most, when the tunnel is pumped out for examination. The amount of this percolation is very slight, even under present conditions, with the lining practically open. While our examinations of the tunnel were under way, samples of water at various points were collected for analysis, and not without some difficulty on account of the small amount of water flowing. These analysis do not indicate that anything of a contaminating nature passes into the tunnel when it is empty.

If the tunnel is completed in accordance with our recommendations, the percolation will be so trifling as to be unimportant, especially when taken in connection with the general absence of organic matter in the wells of those portions of the city which are much more thickly populated than is the ground directly over the tunnel.

SILTING.

It is known that at times the Potomac water contains a large amount of silt. An idea of the amount which may be expected to deposit in the tunnel may be formed from the results of sedimentation which has taken place in the past in the present aqueduct, where it has not been the source of serious trouble. If these deposits occur they should not be allowed to accumulate, but should be removed from time to time, and this can be readily done by means of the four shafts retained and which will be equipped with the necessary hoisting machinery to accomplish this object.

COMPLETION OF THE MAIN TUNNEL.

A portion of the tunnel, about 6,000 feet in length, now contains no lining, and the remainder is provided with a lining of varying section, as shown on one of the accompanying plates. Our estimate for the completion of the tunnel proper is, therefore, naturally divided into two parts.

We have estimated for completing the unlined portions of the tunnel with brickwork of the same form as that used in the lined portions which are provided with an invert. There are large quantities of loose rock in the tunnel at these points, which can be used for the rubble-masonry backing.

Our examination of those portions of the tunnel already lined, taken in connection with the published testimony and supplemented by the statements of others whom we have called before us, shows that there is a great diversity in the character of the lining. In some portions of the tunnel vertical rubble side walls have been built. Where these occur we have been unable to find any void spaces of magnitude behind the walls. In other cases the side walls are built of brick, generally filled on the outside to the crown of the arch with loose packing. Some portions contain a brick invert. As a general rule, empty spaces exist over the crown of the arch. In the westerly part of the tunnel these spaces are comparatively small, but in the easterly portion they are much larger, in some cases extending to more than 10 feet in height. These cavities must be filled with rubble masonry, laid solidly in cement mortar. In some cases timbering exists in the spaces over the arch. The timbering should be taken out in sections and rubble masonry substituted. Where the spaces will not allow of laying rubble masonry, provision has been made for filling the spaces with stone packed by hand and then grouting the whole mass with cement under pressure. In other words, it is intended to fill every space or void now existing in these portions of the tunnel either with cement, grouted rubble, or with rubble masonry laid in cement, thus securing a solid backing everywhere between the lining and the rock.

Where no invert now exists, we recommend a slight excavation of the rock and the building of an invert of Portland cement concrete, smoothly finished.

REENFORCEMENT OF THE ROCK CREEK SECTION.

Experiments made by Major Knight in 1895, and detailed in his report upon this subject, indicate that the covering of rock over the tunnel in the Rock Creek Valley is not sufficient to provide the necessary resistances required, or to prevent serious

percolation. These experiments confirm our own opinion that for a leng 1,000 feet under Rock Creek it will be necessary to provide some special f struction. We have considered various plans, and have come to the con either a subtunnel, built at a considerable distance below the present tun be provided, or that the present tunnel should be lined with cast iron with concrete. A majority of the commission is inclined toward the met The cost of the two plans is practically the same.

ACCESSORIES.

In the course of our examination we have found that it will be neces vide several accessories in connection with the tunnel for the purpose o available and for the purpose of maintaining it in a proper manner after c is completed. We will now allude to these briefly in their order, begin westerly end.

A connection now exists with the 7-foot by-conduit around the distrib voir. A direct connection should also be made with the reservoir, near t shaft, to be controlled by a gatehouse, provided with the necessary gate ances to regulate the flow.

As it is probable that there are voids existing between the brick lini rock surrounding the westerly shaft, the whole of this shaft should be grouted.

The estimate has included a gatehouse covering the shaft, which v hoisting apparatus of simple construction for the raising of material from of the tunnel. The shaft is to be provided with a deep sump protecte paving.

The profile of the tunnel shows a slight summit near the westerly e have provided a small brick structure through this divide for the purpose the water in an easterly direction.

We have deemed it advisable to close the Foundry Branch shaft enti can only be accomplished by providing drainage through the Fayette str in an easterly direction to the Rock Creek shaft. We recommend the c through this summit of a 24-inch masonry pipe properly protected wit Owing to slight percolation in the immediate neighborhood of the Foun shaft, the brick lining at this point is to be reenforced, the shaft lined, g permanently sealed.

All three of the air shafts existing on the line of the tunnel are to l grouted, and protected by suitable coverings.

As the Rock Creek portion is the lowest level in the tunnel, and there a small amount of material over the arch, this point has been selected struction of a 48-inch blow-off, with gates, to empty the tunnel of all the v can be taken out, with the exception of that which must be pumped. to be provided with a metal lining 6 feet in diameter, backed with bri crete. To this lining will be attached a cover of sufficient strength t internal pressure. The shaft will be protected by a brick house provided ing apparatus. A short distance from the shaft an excavation will be r rock to receive a large pump pit surrounded with a heavy wall and con pumping machinery, the whole covered by a substantial superstructure house will contain the necessary boilers for supplying power to the pu will be of sufficient capacity to raise 12,000,000 gallons in twenty-four the level of the tunnel to Rock Creek.

In the Champlain avenue shaft the present timbering is to be repair shaft lined with brick and concrete, containing an opening not less th diameter. A standpipe 25 feet in height should be built upon the top c and the whole covered with a brick house containing the pumping a machinery. A connection with the local sewer should be made at this po the discharge of water onto the surface of the ground.

The Howard or easterly shaft is to be reenforced by a 12-inch brick l the present shaft, and the backing of the shaft grouted throughout its wh There will be a paved sump at the bottom.

A liberal sum has been estimated for the erection of a gatehouse over shaft; it is an important adjunct in connection with the construction of

ESTIMATES.

The following table contains estimates for completing the different portions of the tunnel above alluded to. The estimates include what we deem to be a sufficient allowance for superintendence and contingencies. The total amounts to $897,837. In our judgment the tunnel can be completed in a first-class manner, with all accessories, and ready for operation, for the above sum.

For completing the unlined portion of the tunnel	$181, 010
For completing the portions already lined	278, 012
Reenforcement of tunnel at Rock Creek	138, 000
Total to complete tunnel proper	597, 022
Appurtenances, including shafts, connections, gatehouses, machinery, etc	220, 315
Miscellaneous, including cleaning and coating tunnel and pumping during construction, etc	80, 500
Total	897, 837

The quantities on which we have based the above estimates have been taken from Senate Report No. 2686, part 1, Fiftieth Congress, second session, and from subsequent computations made under our direction by Capt. C. McD. Townsend, Corps of Engineers, U. S. Army, whose services were kindly placed by you at our disposal; also upon the supposition that the whole work will be completed under proper inspection and superintendence within two years.

ADDITIONAL CONSIDERATIONS.

We desire to emphasize the importance of providing proper detailed designs for the construction of the tunnel and all the appliances necessary for its operation and briefly described above.

In connection with the various pumping plants, which from the peculiar profile of the tunnel it is necessary to maintain at various points, we have the following recommendations to make: A selection of men should be made from the permanent force employed upon the maintenance of the completed system. These men should be drilled in the operation of all the machinery connected with the tunnel to fit them for working the pumps promptly whenever it becomes necessary and to insure the maintenance of all the machinery in good order.

Our instructions do not direct any consideration of the construction or sufficiency of the reservoir near the Howard University nor its outlets into the distribution system. We have, therefore, confined ourselves to a study of the tunnel proper and its appurtenances. Realizing, however, that the tunnel and the reservoir form part of one harmonious system and realizing the magnitude of the interests depending upon the security of these works, we recommend that the most careful examination should be made both of the reservoir and of the connections with the distributing system before the tunnel is put into service.

The work recommended by the Board of experts may, then, be classified as follows:

(1) Lining the unlined portion of the tunnel with brick masonry, including invert, and backing same with rubble masonry or concrete.

(2) Constructing an invert in portions of lined tunnel where none was originally built.

(3) Repairing the defective lining already built by removing the timber and loose stone backing and replacing it with rubble masonry or concrete, or grouting where necessary.

(4) Arranging the drainage of the tunnel west of Rock Creek shaft so that all drainage may be collected at the Rock Creek shaft sump.

(5) Lining the portion of the tunnel in the vicinity of Rock Creek shaft with iron, finished on the interior with brick masonry.

(6) Filling the voids in backing, where dry rubble was used, by grouting same.

(7) Constructing the necessary accessories, including gatehouses, blow-off at Rock Creek, air shafts, etc.

(8) In addition to the above, specially mentioned by the Board of experts, the preparation of the Howard University Reservoir for the reception of water and the laying of the mains necessary for furnishing the supply.

At the beginning of the fiscal year work was well under way throughout the whole length of the tunnel, all preliminary work having been completed during the year ending June 30, 1899, and the underground work well started.

The work accomplished during the year was as follows:

1. *Lining unlined portions of tunnel.*—In Foundry Branch west, 415 linear feet of invert, 424 feet of side walls, and 702 feet of arch were completed. In Foundry Branch east, 1,168 linear feet of invert, 952 feet of side walls, and 151 feet of arch were completed. In Rock Creek west, 185 linear feet of invert, 30 feet of side walls, and 30 feet of arch were constructed. In Rock Creek east, 1,033 linear feet of invert, 1,005 linear feet of side walls, and 1,035 feet of arch were completed. In Champlain avenue west, 65 linear feet of invert, 65 feet of side walls, and 65 feet of arch were completed. In Champlain avenue east, 61 linear feet of invert, 61 feet of side walls, and 399 feet of arch were completed. In East Shaft section of the tunnel no new lining was built, as in this portion the lining was all old work, and with the exception of invert had been put in.

2. *Construction of invert in part of tunnel formerly lined.*—In Foundry Branch west, 723 feet of invert were constructed; in Foundry Branch, east 1,028 linear feet. In Rock Creek west, 1,666 linear feet and in Rock Creek east, 633 feet were placed. In Chaplain avenue east, 1,532 linear feet were built,

3. *Repairing the defective lining.*—This work consisted in removing defective backing in old work, repacking the same with good rubble masonry, and grouting the work thus repacked. It was heavy work and involved the removal of all timbering back of the lining, and the cutting and closing of numerous manholes.

Voids were found over the crown of the old arch for its entire length, and many large voids, and in places dangerous roof, were encountered. The work accomplished was as follows: At West Shaft, 209 linear feet of tunnel were rebacked, at Foundry Branch west, 1,427 linear feet, at Foundry Branch east, 962 feet, Rock Creek west, 2,303 feet, Rock Creek east, 2,054 feet, Champlain avenue west, 1,542 feet, Champlain avenue east, 2,294 feet, and East Shaft west, 3,300 feet—in all 14,091 linear feet were repaired by the removal of defective lining, the placing of new rubble masonry in its stead, and filling the voids where no backing was found.

4. *Arranging drainage of tunnel west of Rock Creek.*—This work was accomplished by lowering the summit between Rock Creek and Foundry Branch and removing the summit near West Shaft. This involved the regrading of 2,812 linear feet of tunnel between Rock Creek and Foundry Branch, and 615 linear feet of this work were done during the year, which completes this grading. The removal of the summit near West Shaft involved the removal of the old invert, excavating the rock to proper grade, and relaying the invert. This was done for a length of 76 feet from the West Shaft.

5. *Iron lining of tunnel at Rock Creek.*—Work on the iron lining at Rock Creek was completed during the year. Four hundred linear feet

of lining were placed, backed with rubble masonry, and finished with granolithic lining.

6. *Filling voids in dry-rubble backing.*—This work consisted in grouting the tunnel throughout the whole extent of the old work and at east and west shafts. The grouting was applied by drilling holes at suitable intervals through the lining and forcing the grout in through them by hand pumps. The grout was a mixture of sand and cement in equal parts, with sufficient water added to allow the grout to pass freely through the pumps. The west and east shafts and 11,911 linear feet of old lining were thoroughly grouted.

After completing a section of the tunnel it has been given a wash-coat of cement; 6,255 linear feet of the tunnel have been thus finished.

7. *Accessory works.*—These include the west and east gatehouses, air shafts, and pumps for emptying the tunnel.

The necessary drawings and plans were prepared for the west gatehouse, the east gatehouse, and their appurtenances, and a contract was entered into for furnishing the necessary cut stone. Work on the excavation for the west gatehouse began in March, 1900, and at the close of the fiscal year the masonry was well under way and the cut stone nearly all delivered.

Preparations for excavation for the east gatehouse were completed and excavation for the work begun.

The air shafts at Fayette street, Widows Mite, and Thirteenth street were completed except the surface construction.

A contract has been entered into with The Bacon Air Lift Company for the erection of pumping plants at Champlain avenue and the east shaft; the pumps at these points to be of the pneumatic air-lift type. For the pumping plant at Rock Creek a contract was entered into with the Camden Iron Works. This plant will be of the centrifugal type.

8. *Howard University Reservoir.*—The work at the new reservoir consists in the completion of the stone revetment of the slopes and the repair of the old work.

The revetment was completed except for a portion which can not be done until the gatehouse is near completion. Twelve thousand four hundred and six and thirty-eight one-hundredths square yards of revetment were laid, of which 5,778.10 square yards were repairs to old work.

ORGANIZATION.

For the purpose of supervision the work was separated into two divisions.

The first consisted of all work underground or in the tunnel proper.

The second consisted of all the accessory works, mostly on the surface.

Mr. R. C. Smead, assistant engineer, had charge of the underground work, and Lieut. G. M. Hoffman, Corps of Engineers, was placed in charge of the surface work.

Work underground is continuous during the twenty-four hours, except brick work, which is carried on only from 8 a. m. to 4 p. m.

The tunnel has been lighted, as formerly, by acetylene gas, which has continued to be a satisfactory method, as described in the last Annual Report.

PUMPING.

The efficiency of the work done in the tunnel is shown by the marked decrease in the amount pumped at each shaft. The pumps are located at Foundry Branch, Rock Creek, Champlain avenue, and east shafts.

The daily amount pumped has been as follows:

	1899.	1900.
	Gallons.	*Gallons.*
Foundry Branch shaft	90,201	62,208
Rock Creek shaft	510,105	31,064
Champlain avenue shaft	42,163	15,552
Howard University shaft	143,078	124,416
Total	785,547	233,240

The large reduction at Rock Creek shaft was due to the shutting out from the tunnel, by the iron lining, of the large amount of water which came through the roof of the tunnel from Rock Creek.

PRESENT CONDITION OF TUNNEL.

The tunnel is now finished from the west shaft to Foundry Branch shaft, and from Rock Creek to Champlain avenue, with the exception of one coat of cement wash in Champlain avenue west. Champlain avenue east is complete with the exception of cement wash.

Foundry Branch east is lined, arched, and grouted to Station 12. Rock Creek west is lined, backed, and grouted from the shaft to Station 25 + 75, and from Station 31 + 53 to Station 33 + 63. New lining is now being placed in Foundry Branch east and Rock Creek west, and when completed the tunnel will be finished with the exception of work at the shafts. It is probable that work underground will be completed by January 1, 1901.

ESTIMATES.

The Board of experts in their estimate for the completion and repair of the tunnel gave the amount required for completion of the tunnel proper and its accessories as $897,837. This estimate did not include the amount necessary to complete the Howard University Reservoir, to place it in a condition to be available in connection with the tunnel for the new system of water supply.

It is estimated that $170,673.14 will be required to complete this reservoir, and also that it will require a further expenditure of $439,567.96 to complete the tunnel and accessories. This would make $610,241.10 as necessary on July 1, 1900, to complete the tunnel and reservoir. There was available at this date $448,018.13, leaving a balance necessary to complete the work, including the Howard University Reservoir, of $162,222.97.

The reports of Lieut. G. M. Hoffman, Corps of Engineers, and Mr. R. C. Smead, assistant engineer, are appended, with tables showing the amount and cost of work accomplished, and also plates showing the voids repacked behind the old lining and the portions of the tunnel grouted.

Money statement.

INCREASING THE WATER SUPPLY OF WASHINGTON, D. C.

July 1, 1899, balance unexpended		$658, 160. 03
Amount appropriated by act approved June 6, 1900		139, 034. 34
		797, 194. 37
June 30, 1900, amount expended during fiscal year		316, 788. 67
July 1, 1900, balance unexpended		480, 405. 70
July 1, 1900, outstanding liabilities	$32, 387. 57	
July 1, 1900, amount covered by uncompleted contracts	180, 091. 31	
		212, 478. 88
July 1, 1900, balance available		267, 926. 82
Amount (estimated) required for completion of existing project		162, 222. 97
Amount that can be profitably expended in fiscal year ending June 30, 1902, in addition to the balance available July 1, 1900		162, 222. 97

Abstract of proposals for furnishing and delivering at Howard University Reservoir about 5,100 cubic yards of broken stone and 4,000 tons of riprap stone, for the work of increasing the water supply of Washington, D. C., received in response to advertisement, dated June 30, 1899, and opened July 20, 1899, by Lieut. Col. A. M. Miller, Corps of Engineers.

Name and address.	5,100 cubic yards broken stone, per cubic yard.	4,000 tons (2,240 lbs. each) riprap stone, per ton.	Total.
Charles G. Smith & Son, Washington, D. C. *a*	$2. 20	$1. 80	$13, 420. 00
Owen Patterson, Baltimore, Md	2. 65	2. 65	24, 115. 00
The Cranford Paving Co., Washington, D. C. *b*	2. 10	1. 75	17, 710. 00

a Proposes to furnish about 2,500 cubic yards only. *b* Contract awarded.

Amount available, $20,000.

Abstract of proposals for furnishing and delivering at Rock Creek shaft of Washington Aqueduct Tunnel about 160 tons of special castings for the work of increasing the water supply of Washington, D. C., received in response to advertisement, dated August 23, 1899, and opened September 12, 1899, by Lieut. Col. A. M. Miller, Corps of Engineers.

No.	Name and address.	Special castings; 160 tons (2,240 lbs. each), per ton.	Total.
1	M. J. Drummond & Co., New York City *a*	$44. 00	$7, 040. 00
2	Chamblin & Scott, Richmond, Va	55. 00	8, 800. 00
3	Camden Iron Works, Philadelphia, Pa	78. 00	12, 480. 00
4	Atlanta Machine Works, Atlanta, Ga	74. 70	11, 952. 00
5	The Hoefinghoff and Laue Foundry Co., Cincinnati, Ohio	61. 20	9, 792. 00

a Contract awarded.

Amount available, $10,000.

Abstract of proposals for furnishing and delivering at shafts of Washington Aqueduct Tunnel about 23,000 barrels of cement and 7,000 cubic yards of sand for the work of increasing the water supply of Washington, D. C., received in response to advertisement, dated October 25, 1899, and opened November 20, 1899, by Lieut. Col. A. M. Miller, Corps of Engineers.

No.	Name and address.	23,000 barrels cement, per barrel.	7,000 cubic yards sand, per cubic yard.	Total.
1	Cumberland Valley Cement Co., Washington, D. C	$1. 05		$24, 150. 00
2	James H. McGill, Washington, D. C. *a*	. 87		20, 010. 00
3	John B. Lord, Washington, D. C		$1. 80	12, 600. 00
4	Columbia National Sand Dredging Co., Washington, D. C. *a*		1. 75	12, 250. 00

a Contract awarded.

Amount available, $36,000.

Abstract of proposals for furnishing and delivering cut stone for gatehouses for the work of increasing the water supply of Washington, D. C., received in response to advertisement, dated November 15, 1899, and opened December 14, 1899, by Lieut. Col. A. M. Miller, Corps of Engineers.

No.	Name and address.	Distributing reservoir. 584 cubic yards cut stone, per cubic yard.	New reservoir. 1,116 cubic yards cut stone, per cubic yard.	Total.
1	Wm. H. Mackey, 66 Broadway, New York, N. Y	$34.56	$33.66	$57,747.60
2	James C. McGuire and Chas. W. Hall, 28 Cortlandt street, New York, N. Y	36.00	39.50	65,106.00
3	A. B. Cook, Petersburg, Va	34.02	38.88	63,257.76
4	J. Merrick Horn, Wilmington, Del	47.00	47.00	79,900.00
5	McIlvain-Unkefer Co., Pittsburg, Pa. *a*	30.44	30.44	51,748.00
6	J. F. Manning & Co., Washington, D. C	35.95	35.95	61,115.00
7	McClenahan & Bro., Granite Co., Port Deposit, Md	47.75	49.14	82,726.24
8	Venable Bros., Atlanta, Ga	34.00	33.00	56,684.00
9	Rogers & McBean, New York, N. Y	54.00	54.00	91,800.00
10	John Pierce, New York, N. Y	38.61	44.01	71,663.40
11	The Guilford and Watersville Granite Co., Baltimore, Md	47.70	49.20	83,764.00

a Contract awarded.

Amount available, $60.000.

Abstract of proposals for furnishing and delivering at new reservoir, distributing reservoir, and shafts of Washington Aqueduct Tunnel about 7,000 barrels of American Portland cement and 38,000 barrels of natural hydraulic cement and about 7,500 cubic yards of sand for work of increasing the water supply of Washington, D. C., received in response to advertisement dated March 8, 1900, and opened April 7, 1900, by Lieut. Col. A. M. Miller, Corps of Engineers.

No.	Name and address.	Cement. American Portland. (7,000 barrels) per barrel.	Brand.	Natural hydraulic. (38,000 barrels) per barrel.	Brand.
1	Alexander Y. Hanna & Co., Philadelphia, Pa.	$2.46	Climax		
2	James H. McGill, Washington, D. C.	2.33	Atlas	*a* $0.87	Cumberland Hydraulic.
3	J. G. Waters & Son, Washington, D. C. In barrels.	2.44	Star		
	In bags	2.24			
4	William J. Donaldson, Philadelphia, Pa. *a*.	2.30	Alpha		
5	Cranford Paving Co., Washington, D. C.	2.58	Vulcanite		
6	Lawrenceville Cement Co., New York, N. Y.			1.00	
7	Sparrow, Fridenburg & Co., New York, N. Y.	2.4775	Teutonia		

No.	Name and address.	Sand (7,500 cubic yards). Per cubic yard.	Location.	Total.	Remarks.
1	Alexander Y. Hanna & Co., Philadelphia, Pa.			$17,220.00	No guaranty.
2	James H. McGill, Washington, D. C.	$1.70		62,120.00	
3	J. G. Waters & Son, Washington, D. C. In barrels.			17,080.00	
	In bags			15,680.00	
4	William J. Donaldson, Philadelphia, Pa. *a*.			16,100.00	
5	Cranford Paving Co., Washington, D. C.			18,060.00	
6	Lawrenceville Cement Co., New York, N. Y.			41,800.00	No revenue stamps.
7	Sparrow, Fridenburg & Co., New York, N. Y.			17,342.50	
8	The Lincoln-Richards Sand Co., Washington, D. C. *a*	1.30	Potomac River	9,750.00	

a Contract awarded.

Amount available, $58,910.

Abstract of proposals for furnishing and installing pumping plants for the Washington Aqueduct Tunnel received in response to advertisement dated March 10, 1900, and opened April 10, 1900, by Lieut. Col. A. M. Miller, Corps of Engineers.

No.	Name and address.	Pumping plants.			
		One centrifugal at Rock Creek shaft.	One air lift at Champlain Avenue shaft.	One air lift at east shaft.	Total.
1	Camden Iron Works, Camden, N. J. *a*	$10,500.00			$10,500.00
2	Burhorn & Granger, New York, N. Y	7,250.00			7,250.00
3	Morris Machine Works, Baldwinsville, N. Y	9,676.19			9,676.19
4	Pneumatic Engineering Co., New York, N. Y. (Harris system)		$15,395.00	$17,068.00	32,463.00
5	Pneumatic Engineering Co., New York, N. Y		21,235.00	24,242.00	45,477.00
6	Bacon Air Lift Co., New York, N. Y. *a*		29,000.00	31,300.00	60,300.00

a Contract awarded.

Amount available (about) $70,800.

Abstract of contracts in force June 30, 1900.

Name.	Date of approval.	Date of beginning delivery.
Frederick Brick Works, for brick	Mar. 7, 1899	Mar. 24, 1899
Cranford Paving Co., for broken stone	Aug. 25, 1899	Sept. 18, 1899
Cranford Paving Co., for riprap stone	do	Oct. 5, 1899
Columbia National Sand Dredging Co., for sand	Dec. 22, 1899	Dec. 23, 1899
McIlvain-Unkefer Co., for cut stone	Jan. 18, 1900	Mar. 26, 1900
James H. McGill, for cement	May 3, 1900	Apr. 22, 1900
Wm. J. Donaldson, for Portland cement	May 9, 1900	May 12, 1900
Camden Iron Works, for pumping plant	June 4, 1900	
Bacon Air Lift Co., for pumping plants	June 13, 1900	

Appendix I.

REPORT OF MR. R. C. SMEAD, ASSISTANT ENGINEER.

Office of the Washington Aqueduct,
Washington, D. C., July 9, 1900.

Colonel: I have the honor to submit the following report of work done on the tunnel during the fiscal year ending June 30, 1900:

At the west shaft.—The sump was excavated and lined with brick; the depth of sump as completed is 7 feet.

The summit in the tunnel near the west shaft was excavated and new invert constructed so as to carry the drainage toward the Foundry Branch shaft. The excavation was 76 feet long; greatest depth, 18 inches.

The tunnel lining between the west shaft and Station 2+09 was packed with rubble masonry over crown of arch; the side walls and arch grouted; the lining thoroughly cleaned and covered with two coats of Portland-cement wash.

At Foundry Branch shaft.—In the west heading 415 feet of new invert, 424 feet of new side walls, and 702 feet of new arch were constructed. Seven hundred and twenty-three feet of invert were constructed in old arch.

One thousand four hundred and twenty-seven feet of old arch were repaired, where possible, with rubble-masonry backing and then thoroughly grouted. Four hundred and twelve feet of old stone side walls were plastered.

Two thousand one hundred and thirty-two feet of lining were covered with two coats of Portland-cement wash.

This heading is entirely completed except 76 feet at the shaft.

In the east heading the work of excavating the bottom of the tunnel so as to carry the drainage to the Rock Creek sump was completed.

Six hundred and fifteen linear feet of grading were done.

One thousand seven hundred and ninety-eight feet of new invert, 1,852 feet of new side walls, and 151 feet of new arch were constructed.

One thousand and twenty-eight feet of new invert were constructed in old lining.

Nine hundred and sixty-two feet of the old arch were repaired with rubble masonry and then thoroughly grouted.

Six hundred and thirty feet of old stone side walls were plastered.

At Rock Creek shaft.—In the west heading 185 feet of new invert, 30 feet of new side walls, and 180 feet of new arch were constructed. One thousand nine hundred and twenty-five feet of invert were built in old lining.

Two thousand three hundred and three feet of old arch were packed with rubble masonry and thoroughly grouted.

Three hundred and thirty feet of the old side walls were plastered, and two coats of Portland-cement wash were put on 800 feet of the lining.

Two hundred and twenty linear feet of cast-iron lining were placed in the tunnel under Rock Creek.

In the east heading 1,033 feet of new invert, 1,005 feet of new side walls, and 1,035 feet of new arch were constructed.

Six hundred and thirty-five feet of invert were constructed in old lining.

Two thousand and fifty-four feet of old arch were packed with rubble masonry and then thoroughly grouted.

Six hundred and forty-eight feet of the old stone side walls were plastered.

Two coats of Portland cement were put on 3,114 feet of the lining.

One hundred and eighty feet of cast-iron lining were placed in the tunnel just east of the shaft.

This heading is entirely completed.

At Champlain avenue shaft.—In the west heading 65 feet of new invert side walls and arch were constructed.

One thousand five hundred and forty-two feet of the old arch were packed with rubble masonry, and 1,988 feet of the old arch were grouted.

Twenty-two cords of timber were taken out from back of the old arch.

In the east heading 61 feet of new invert and side walls and 399 feet of new arch were constructed. One thousand five hundred and thirty-two feet of invert were constructed in old arch.

Two thousand two hundred and ninety-four feet of old arch were packed with rubble masonry and grouted.

One thousand eight hundred and twenty feet of old stone side walls were plastered.

Three and one-half cords of timber were taken out from back of old arch.

At the east shaft.—The old arch was repaired with rubble masonry for a distance of 3,300 feet. One thousand and seventy-four feet of the old arch were grouted.

One hundred and forty-eight cords of timber were taken from back of old arch.

The east shaft was thoroughly grouted.

The tables given herewith show the cost and amount of work done during the year and the cost and total amonnt of work done since the work commenced.

Very respectfully, your obedient servant,

R. C. SMEAD,
Assistant Engineer.

Lieut. Col. A. M. MILLER,
Corps of Engineers, U. S. A.

Table showing amount of work performed (Aqueduct Tunnel).

Class of work.	Year ending June 30, 1899.	Year ending June 30, 1900.	Total.
Trimming .... linear feet..	5,919	....	5,919
Track laid .... do....	20,594	....	20,594
Material removed .... cubic yards..	29,678	8,578	38,256
Timber removed from back of arch .... cords..	54¼	173½	238
Brick laid .... number..	784,712	1,810,167	2,594,879
New invert lined .... feet..	1,465	3,557	5,022
New side wall lined .... do....	1,435	3,167	4,602
New arch lined .... do....	784	2,532	3,316
New invert placed in old lining .... do....	442	5,841	6,283
Old lining repaired with rubble masonry .... do....	446	14,091	14,537
Concrete in place .... cubic yards..	943	3,926	4,869
Masonry backing for old arch .... do....	1,573	9,174	10,747
Masonry backing for new arch .... do....	1,236	2,814	4,050
Iron lining at Rock Creek .... feet..	100	400	500
Stone side walls plastered .... linear feet..	....	3,840	3,840
Stone crushed .... cubic yards..	900	4,634	5,534
Drainage changed from Foundry Branch to Rock Creek.. linear feet...	2,812	615	3,427
Old arch grouted .... do....	....	11,911	11,911
Old arch grouted, cement used .... barrels..	....	24,248	24,248
Grouting west shaft, cement used .... do....	....	708	708
Grouting east shaft, cement used .... do....	....	1,144	1,144
Cement, washing tunnel (two coats) .... linear feet..	....	6,255	6,255
Sand taken out of Rock Creek .... cubic yards..	....	577	577

Table showing holes cut in brick lining of tunnel.

Location.	Holes cut.						Total holes cut.
	By the commission.		For repairs.		Total.		
	Arch.	Side walls.	Arch.	Side walls.	Arch.	Side walls.	
West shaft	7	....	....	....	7	....	7
Foundry Branch, west	40	4	4	....	44	4	48
Foundry Branch, east	30	....	7	....	37	....	37
Rock Creek, west	57	6	56	....	113	6	119
Rock Creek, east	71	2	35	....	106	2	108
Champlain avenue, west	68	6	50	6	118	12	130
Champlain avenue, east	52	....	81	7	133	7	140
Howard University	79	13	117	207	196	220	416
Total	404	31	350	220	754	251	1,005

The total monthly amount of trimming, track laying, excavation, and masonry construction since the commencement of the work is as follows:

Date.	Trimming.	Track laid.	Material removed.	Timber removed from back of old arch.	Brick used.	New brick lining.		
						Invert.	Side wall.	Arch.
1898.	*Feet.*	*Feet.*	*Cu. yds.*	*Cords.*		*Feet.*	*Feet.*	*Feet.*
September	75	....	....	....	....	....	....	....
October	397	800	850	....	....	....	....	....
November	1,534	8,105	3,664	....	....	....	....	....
December	2,316	10,694	3,803	....	....	....	....	....
1899.								
January	1,550	1,000	5,992	....	....	....	....	....
February	25	....	2,990	....	....	....	....	....
March	....	....	1,063	....	....	....	123	32
April	....	....	2,442	16	190,000	417	417	224
May	....	....	3,204	35	251,000	655	655	438
June	....	....	3,544	13½	102,000	393	240	90
July	....	....	3,461	9	94,000	....	....	210
August	....	....	487	13	168,000	61	120	250
September	....	....	425	....	147,000	155	126	308
October	....	....	419	3½	151,000	360	303	215
November	....	....	230	16	92,000	46	....	185
December	....	....	294	19	173,000	652	....	....
1900.								
January	....	....	1,200	28	160,000	330	210	122
February	....	....	398	26	226,950	496	766	231
March	....	....	810	12	261,822	605	920	309
April	....	....	494	32	171,850	67	39	485
May	....	....	479	15	164,545	155	....	67
June	....	....	7	....	241,712	630	630	150
Total	5,915	20,594	38,256	238	2,594,879	5,022	4,549	3,316

Date.	Invert placed in old lining.	Old lining repaired.	Concrete in place.	Rubble masonry in place.		Iron lining.	
				Old arch.	New arch.		
1899.	*Feet.*	*Feet.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Feet.*	*Rings.*
March	....	....	55	....	52	....	....
April	....	77	197	192	293	....	....
May	265	193	265	690	509	20	5
June	177	176	426	691	382	84	21
July	408	798	426	474	340	76	19
August	930	1,892	300	1,044	286	84	21
September	526	2,070	61	1,150	388	64	16
October	35	1,245	339	696	184	40	10
November	506	2,049	522	922	114	32	8
December	878	520	754	732	208	84	21
1900.							
January	236	675	423	899	263	16	4
February	235	1,522	323	823	268	....	....
March	....	871	412	940	502	....	....
April	64	1,365	276	1,052	194	....	....
May	1,764	584	90	422	6	....	....
June	259	....	....	....	61	....	....
Total	6,283	14,537	4,869	10,727	4,050	500	125

Date.	Stone side walls.		Old work grouted.		Tunnel cement washed.
	Constructed.	Plastered.	Distance.	Cement.	
1899.	*Feet.*	*Feet.*	*Feet.*	*Barrels.*	*Feet.*
September	53	....	24	155	....
October	....	....	2,059	3,048	....
November	....	....	1,130	2,672	....
December	....	650	1,956	2,855	....
1900.					
January	....	541	1,152	3,259	....
February	....	805	1,575	3,347	....
March	....	710	....	995	....
April	....	250	1,400	2,253	2,092
May	....	294	1,920	3,875	675
June	....	610	695	1,789	3,488
Total	53	3,840	11,911	24,248	6,255

Expenses Washington Aqueduct Tunnel.

Items.	Year ending June 30, 1899.		Year ending June 30, 1900.		Total.
	Labor.	Material.	Labor.	Material.	
Tools, machinery, and material	$603.00	$7,006.71	....	$3,306.04	$10,915.75
Erecting and maintaining buildings	1,334.00	1,596.61	$31.00	67.99	3,029.60
Repairing road to Rock Creek	427.00	396.50	665.00	219.94	1,708.44
Excavating and retimbering shafts and building head houses	3,865.00	3,308.76	114.00	17.60	7,305.36
Building and repairing cars	340.00	1,703.28	360.00	213.90	2,617.18
Experimental arch at Rock Creek	117.00	233.50	....	....	350.50
Erecting and maintaining gas plant and lighting tunnel	644.00	6,602.78	536.00	4,008.32	11,791.10
First pumping out of tunnel	1,388.00	545.90	....	....	1,933.90
Pumping out tunnel during construction	6,470.00	1,903.58	6,328.00	315.15	15,016.73
Trimming tunnel for lining	13,508.00	1,076.89	....	....	14,584.89
Excavating and track laying	21,570.00	5,077.51	7,721.00	374.01	34,742.52
Cutting drainage channel from Foundry Branch to Rock Creek:					
Trimming	13,094.00	627.70	7,076.00	370.91	34,132.72
Excavating	12,674.00	290.11			
Cleaning out toothing in old brickwork	326.00	290.11	....	....	616.11
Cleaning snow and ice from roads	138.00	38.50	....	....	176.50
Hauling coal during blizzard	63.00	....	....	....	63.00
Taking out rail left by contractors	24.00	162.61	....	....	186.61
Making centers for brickwork	143.00	669.26	....	....	812.26
Building brick and rubble backing	12,097.00	9,657.88	27,779.00	36,034.25	85,568.13
Concrete under invert	2,823.00	1,984.29	13,700.00	8,390.96	26,898.25
Repairing old arch with rubble masonry	4,832.00	2,820.80	38,614.89	14,895.15	61,162.84
Placing iron lining under Rock Creek	1,522.00	4,312.18	7,497.00	17,639.28	31,978.46
Iron on hand not laid	....	1,008.00	....	....	
Grouting in tunnel	....	....	24,375.00	24,843.60	49,218.60
Grouting in west shaft	....	....	404.00	948.96	1,352.96
Grouting in east shaft	....	....	1,975.00	1,244.28	3,219.28
Underpinning old side walls	....	....	551.00	294.35	845.35
Excavating sand at Rock Creek	....	....	364.00	....	364.00
Invert and sump at west shaft	....	....	816.00	197.25	1,013.25
Crushing stone	....	....	1,929.85	189.46	2,119.31
Plastering old stone side walls	....	....	1,961.00	453.92	2,414.92
Cement washing west shaft	....	....	40.00	5.40	45.40
Cement washing tunnel	....	....	1,244.00	455.35	1,699.35
Engineering and office expenses	7,922.43		11,579.28		19,501.71
Total	....	....	....	....	427,381.98

Appendix II.

REPORT OF LIEUT. G. M. HOFFMAN, CORPS OF ENGINEERS.

Office of the Washington Aqueduct,
Washington, D. C., July 1, 1900.

Colonel: I have the honor to submit the following report on the work of which I have had active charge, under your direction, during the fiscal year ending June 30, 1900.

NEW RESERVOIR.

Delivery of broken stone and rubble for completing the paving of the reservoir slopes was begun September 18, 1899, and the work of laying the paving was started October 1, 1899. All work was done by day labor, materials being, in general, furnished by contract.

A total of 12,406.38 square yards of paving was laid, of this amount 6,628.28 square yards was new paving and 5,778.10 square yards was old paving which had to be replaced where slips or washouts had occurred or where the broken stone layer had been omitted.

The paving consists of a layer of broken stone about 8 inches thick, on top of which blocks of rubblestone about 10 inches thick are placed. The paving was carried down to the bottom of the reservoir and a good footing was obtained at the toe of the slope.

In grading for the paving 16,651.5 cubic yards of material were removed.

The broken stone delivered amounted to 3,258.51 cubic yards, of which 2,890.51 cubic yards were furnished by contract at $2.10 per cubic yard and 368 cubic yards were broken by hand at 50 cents per cubic yard, the stone for the latter being obtained from refuse piles in the bottom of the reservoir. Spawls from refuse piles were used in place of broken stone to the amount of 84 cubic yards, at a cost of 31 cents per cubic yard.

The rubblestone used amounted to 2,023.24 tons, of which 1,366.24 tons were furnished by contract, at $1.75 per ton, and 808 tons were obtained from refuse stone piles, at a cost of $0.543 per ton.

The paving has been completed except for a section in front of the gatehouse and two sections where slips have occurred and which will not be replaced until subsidence has stopped.

The removal of stone and muck piles in the reservoir was commenced. Much of the stone and spawls was used for constructing and repairing roads; the balance, amounting to 2,929 cubic yards, was carted from the reservoir, at a cost of $0.3053 per cubic yard.

The circulating conduits in the reservoir were staked out; 1,000 linear feet of road were constructed along them for the delivery of construction materials, and investigation was made of the character of the foundation by digging test pits, to furnish the necessary data for drawing up a project for the design and construction of the conduits. This project is almost ready to be submitted.

The work of completing the reservoir bank in front of the gatehouse was commenced June 11, 1900. A section of 306 square yards of old paving that would be covered by the embankment was torn up, at a cost of $0.2375 per yard; the broken stone and rubble thus saved will be utilized in paving the new slope. Muck and vegetation to the amount of 193 cubic yards were dug from the foundation of the embankment and carted out of the reservoir, at a cost of $0.3172 per cubic yard.

The end of the 75-inch main leading from the reservoir was opened up and the accumulation of sand in the main was removed. The excavation amounted to 699 cubic yards, and cost, including timber for shoring, $0.4589 per cubic yard. The joints of the main were recalked.

AIR SHAFTS.

The three air shafts of the Aqueduct Tunnel were completed, except for the surface construction. They are designated as the Fayette street, the Widows Mite, and the Thirteenth street air shafts, and are, respectively, 156 feet, 152.33 feet, and 128.25 feet deep. Each shaft was constructed by boring a hole 10 inches in diameter through from the surface; the hole was cased from the surface to the rock stratum with a 10-inch drive pipe; a 6-inch wrought-iron pipe, reaching from the surface to the crown of the arch of the tunnel, was centered in the 10-inch boring, and the space between the two was filled with cement grout. A strong and permanently lined

shaft is thus obtained, and the inevitable rusting-out of the wrought-iron piping is rendered immaterial. The boring of the air shafts was done by contract, all tools being furnished by the contractor. All material was furnished by the United States.

EAST SHAFT GATEHOUSE.

This work was commenced May 1, 1900.

The site was cleared and leveled off; derricks and engines for unloading cut stone and excavating for the foundation were installed; excavation for the south wall was started; 3,512.5 cubic yards of material were removed. The work is being done by day-labor. The materials are to be furnished by contract, except the broken stone for concrete, which will be crushed from the refuse piles at Rock Creek shaft.

WEST SHAFT GATEHOUSE.

This work was commenced March 6, 1900. The site was fenced in and cleared, and the auxiliary gatehouse was torn down.

The excavation for the substructure was completed; the north, east, and west outside concrete walls were constructed and the concrete beneath the interior walls and wells was placed. The excavation of earth and old masonry amounted to 4,132½ cubic yards; the concrete work amounted to 669⅓ cubic yards, and the brickwork amounted to 3.4 cubic yards. The cut stone for the interior well walls has been delivered, except for a small percentage of the top course. The work is being done by day-labor. The materials are being furnished by contract, except the broken stone for concrete, which is being crushed from the refuse piles at Foundry Branch shaft.

PUMPING PLANTS.

After a close study of the problem of pumping out the tunnel for cleaning, inspection, or repair, a decision was reached in favor of a centrifugal pumping plant for Rock Creek shaft and air-lift pumping plants for Champlain avenue and east shafts. Contracts for furnishing and installing these plants have been let, and plans for the power houses, which are to be constructed by the United States, have been prepared in part.

OTHER ACCESSORIES.

Drawings and specifications have been prepared, and advertisement is about to be made for the ironwork for completing Rock Creek and Champlain avenue shafts; for connections at west shaft and east shaft gatehouses with the distributing system, and for all necessary valves and sluice gates.

Tables are submitted showing in detail the amount of work done and the distribution of the cost of the same.

Very respectfully, your obedient servant,

G. M. Hoffman,
First Lieutenant, Corps of Engineers.

Lieut. Col. A. M. Miller,
Corps of Engineers, U. S. A.

Amount of work performed (accessories).

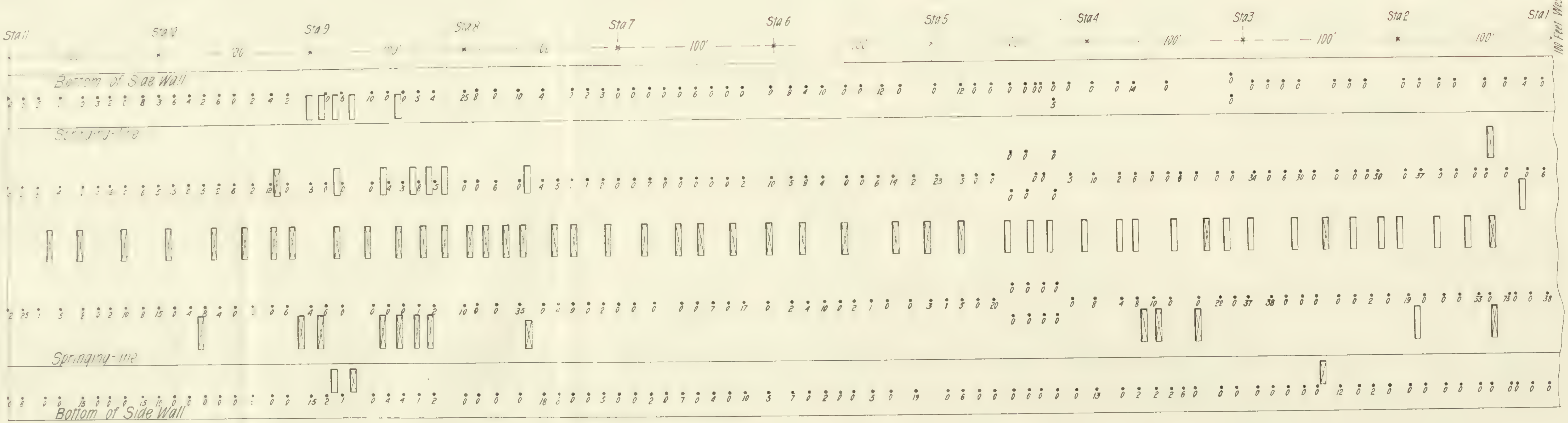
Items.	1899.			1900.	
	Oct.	Nov.	Dec.	Jan.	Feb.
New reservoir:					
Subgrading for paving ....square yards..	1,339.50	1,566	500	1,550.50	1,297.60
Broken-stone layer for paving..........do....	880	1,577	333	1,111.50	1,307.90
Finished paving ....do....	809	1,784.50	355	938.30	1,018
Old paving torn up ....do....	....	....	1,631	564	1,101
Excavation for subgrading.......cubic yards..	1,232.50	3,950	2,123	584	1,003
Stone broken by hand..........do....	....	72.50	295.50	....	....
Spawls used instead of broken stone ....do....	....	84	....	....	....
Hand-broken stone used..........do....	....	72.50	....	60	31
Rubble used from refuse pile ....tons..	....	196	151	....	....
Excavation of sand, etc., 75-inch main, cubic yards.	....	....	....	....	699
Air shafts:					
Fayette street boring..........feet..	....	156	....	....	....
Widows Mite boring ....do...	....	....	152.33	....	....
Thirteenth street boring..........do...	....	....	....	128.25	....

INCREASING THE WATER SUPPLY OF WASHINGTON, D.C.

REPAIR OF DEFECTIVE WORK AT CHAMPLAIN AVENUE WEST.

LONGITUDINAL SCALE FEET

TRANSVERSE SCALE FEET



DEVELOPMENT OF TUNNEL

EXCLUSIVE OF INVERT

Note:– The manholes which are shown thus: ▯ were cut under supervision of the Board of Experts, the remaining ones were cut during repair of tunnel.
The manholes were used to remove cord wood and repair packing.

The numbers below circles indicate the number of barrels of cement used in grouting.
The grout mixture was composed of one part cement to one part sand.

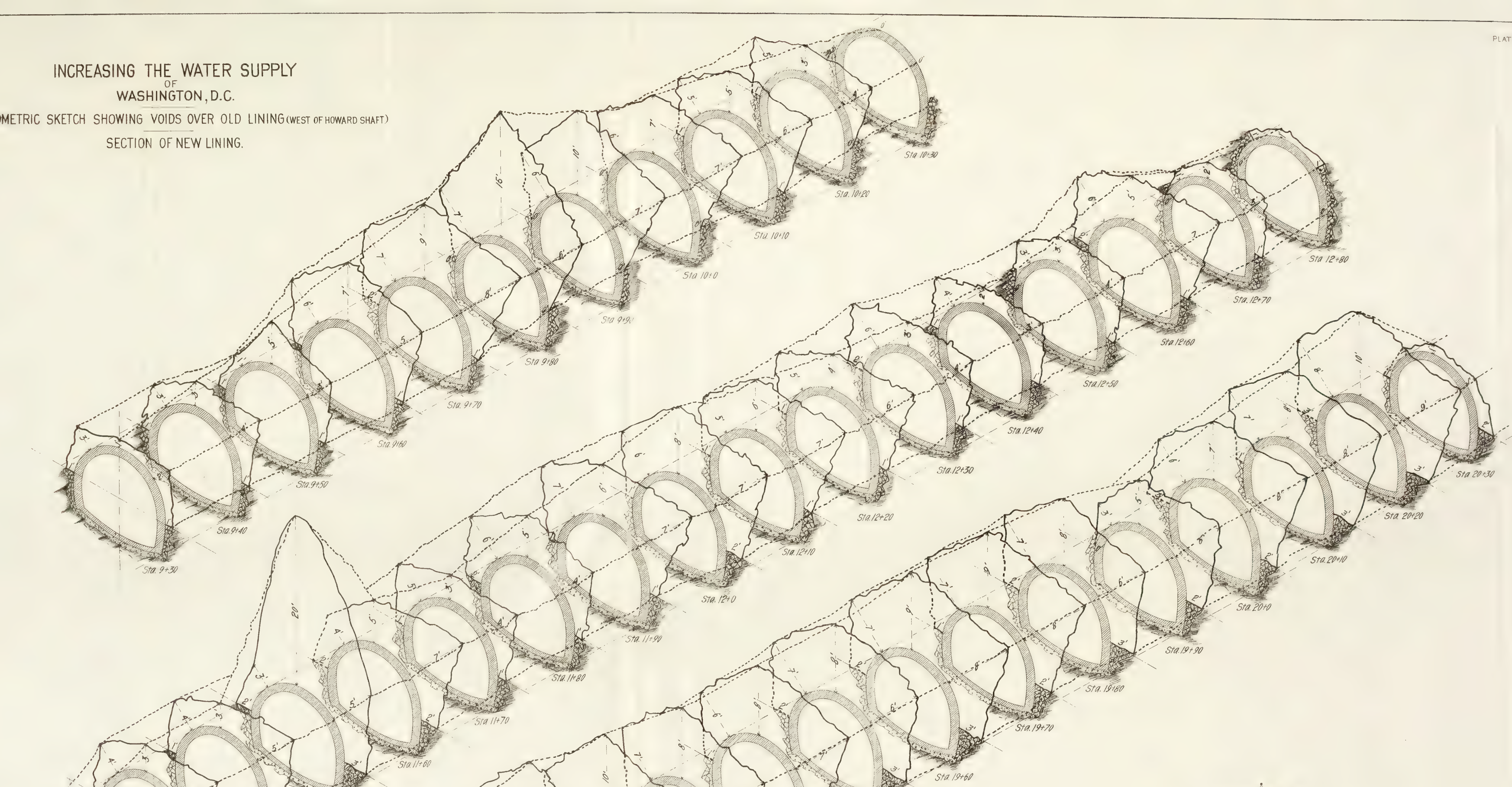
To Accompany Annual Report for the Year 1900

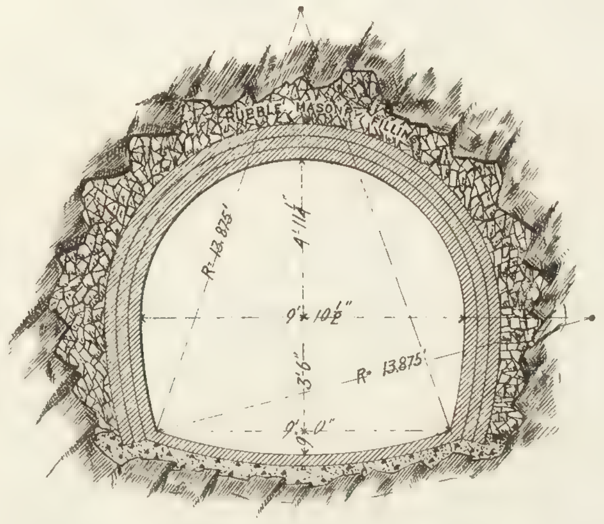
A. M. Miller
Lt Col Corps of Engineers

INCREASING THE WATER SUPPLY OF WASHINGTON, D.C.

ISOMETRIC SKETCH SHOWING VOIDS OVER OLD LINING (WEST OF HOWARD SHAFT)

SECTION OF NEW LINING.





TRANSVERSE SECTION OF TUNNEL
SHOWING
NEW LINING
SCALE — FEET

To Accompany Annual Report for the Year 1900

A. M. Miller
Lt. Col. Corps of Engineers.

Amount of work performed (accessories)—Continued.

Items.	1900.				Totals.
	Mar.	Apr.	May.	June.	
New reservoir:					
Subgrading for paving ....square yards..	2,583.80	1,296.90	2,158.50	....	12,292.80
Broken-stone layer for paving..........do....	2,494	1,571	2,828.50	323	12,428.90
Finished paving ....do....	2,607.08	2,015.29	1,826.80	1,022.41	12,406.38
Old paving torn up ....do....	2,482.10	....	....	....	5,778.10
Excavation for subgrading.......cubic yards..	1,477	3,160	3,122	....	16,651.50
Stone broken by hand..................do....	....	....	....	....	368
Spawls used instead of broken stone ....do....	....	....	....	....	84
Hand-broken stone used................do....	115	127	69	....	471.50
Rubble used from refuse pile ....tons..	....	....	296	165	808
Stone and muck removed ....cubic yards..	....	....	390	2,539	2,929
Roads built for circulating conduits..linear feet	....	....	....	1,000	1,000
Old paving torn up for bank at gatehouse, square yards	....	....	....	306	306
Excavation for bank at gatehouse..cubic yards..	....	....	....	193	193
Excavation of sand, etc., 75-inch main....do....	....	....	....	....	699
Air shafts:					
Fayette street boring ....feet..	....	....	....	....	156
Widows Mite boring ....do...	....	....	....	....	152.33
Thirteenth street boring ....do...	....	....	....	....	128.25
East Shaft gatehouse:					
Excavation for foundation ....cubic yards..	135	1,033	611	1,733.50	3,512.50
West Shaft gatehouse:					
Excavation for foundation ....do....	358	1,526	1,121	1,127⅓	4,132⅓
Sand delivered ....do....	....	....	140.25	144	284.25
Brickwork ....do....	....	....	3.40	....	3.40
Cement delivered ....barrels..	....	....	610	900	1,510
Concrete in place..................cubic yards..	....	....	298	371⅓	669⅓
Broken stone delivered..................do....	....	....	312.25	322	631.25
Cut stone delivered (not laid) ....do....	49	264.27	212.73	36.80	562.80

Expenses (accessories).

Item.	Labor.	Material.	Total.
New reservoir:			
Finished paving..	$7,434.16	$8,513.49	$15,947.65
Tearing up old pavement	382.64	....	382.64
Excavation for subgrading....................................	3,010.35	148.02	3,158.37
Breaking stone by hand.......................................	184.00	....	184.00
Hauling and spreading spawls.................................	26.04	....	26.04
Hauling and spreading hand-broken stone......................	189.56	....	189.56
Hauling rubble from refuse piles	438.80	....	438.80
Miscellaneous—watchman, carpenter's work, etc................	1,058.00	....	1,058.00
Removal of stone and muck piles..............................	894.27	....	894.27
Constructing road for circulating conduits...................	257.30	16.55	273.85
Constructing reservoir bank at gate house....................	133.93	....	133.93
Excavation, calking, etc., 75-inch main	273.87	46.94	320.81
Air shafts:			
Completing 3 air shafts (labor by contract)	1,404.98	869.17	2,274.15
Inspection...	185.50	....	185.50
East shaft gate house:			
Excavation for substructure	1,177.79	675.66	1,853.45
Expenditures for plant.......................................	....	1,700.56	1,700.56
West shaft gate house:			
Excavation for and construction of substructure	3,551.10	5,367.31	8,918.41
Crushing broken stone..	336.15	....	336.15
Cut stone for interior chambers (not laid)...................	....	17,131.63	17,131.63
Pumping plant:			
Investigation, printing, and advertising.....................	....	187.37	187.37
Engineering and office expenses..............................	2,486.72	....	2,486.72
Total	23,425.16	34,656.70	58,081.86

G G G 3.

INVESTIGATING WATER SUPPLY OF WASHINGTON, DISTRICT OF COLUMBIA.

This work was conducted under an act approved June 30, 1898, which contained the following clause:

To enable the proper officer of the Government having charge of the Washington Aqueduct and the water supply of the city of Washington to make an investigation of the feasibility and propriety of filtering the water supply of Washington and to submit to Congress a full and detailed report thereon, and to meet all necessary expenses of said investigation, three thousand dollars. Said report shall be accompanied by a detailed estimate of the cost of the work required, and in making the investigation and in the preparation of this report the Chief of Engineers, United States Army, shall be associated with the proper officer of the Government in the charge of the Aqueduct as consulting engineer.

In addition to the above appropriation of $3,000 an additional appropriation of $5,000 was given by an act making appropriations to provide for the expenses of the government of the District of Columbia for the fiscal year ending June 30, 1900, and for other purposes:

For additional amount to enable the proper officer of the Government having charge of the Washington Aqueduct and the water supply of the city of Washington to make an investigation of the feasibility and propriety of filtering the water supply of Washington, and to submit to Congress a full and detailed report thereon, and to meet all necessary expenses of said investigation, five thousand dollars, to be immediately available.

The work for the fiscal year consisted in the investigation of the subject of the filtration of the Washington water supply by practical experiments in the filtration of the water as delivered from the distributing reservoir.

Owing to the limited amount of funds the investigation was confined to the results obtained by slow and rapid filtration, the latter involving the use of sulphate of alumina as a coagulant.

It was found that the Potomac water as supplied to the city of Washington could not be satisfactorily filtered by the English or slow sand filtration, but that good results could be obtained by the rapid or American method.

A report was submitted (Senate Doc. No. 259, Fifty-sixth Congress, first session) on March 28, 1900, and it was recommended that the American system be adopted.

Money statement.

INVESTIGATING WATER SUPPLY OF WASHINGTON, D. C.

July 1, 1899, balance unexpended	$6,083.37
June 30, 1900, amount expended during fiscal year	6,083.37

G G G 4.

WASHINGTON AQUEDUCT, DISTRICT OF COLUMBIA, FILTRATION PLANT.

By act approved June 6, 1900, an appropriation of $200,000 was made—

For establishing those portions of a filtration plant which are essential to the operation of either system of filtration adopted, including necessary land, grading, masonry, and appurtenances.

The necessary studies resulted in the submission by the engineer officer in charge of a project for the purchase of land for a filter plant and clear-water basin which would be essential to the operation of either system of filtration adopted.

In the report on the feasibility and propriety of filtering the water supply of Washington, D. C., estimates were submitted for two systems of filtration. The estimate for the slow or English system was $2,461,338, for the rapid or American system, $1,081,377. It would appear from the wording of the above appropriation that Congress, although expressing approval of some system of filtration as necessary, has not definitely decided which system should be adopted.

With the appropriation of $200,000, made by act approved June 6, 1900, probably sufficient land may be purchased for the American system, but for the English system the land alone is estimated to cost $555,588.

In either case the plant would require two years at least to erect. Therefore, in the case of the English system, $555,588 plus one-half of the remainder of the estimate—$952,875, or in all $1,508,463, or, say, $1,500,000—could be advantageously expended during the fiscal year ending June 30, 1902.

In case the American system be adopted $700,000 can be advantageously expended, or $500,000 in addition to the $200,000 already available. The above amounts are asked for in the estimates.

Money statement.

Amount appropriated by act of June 6, 1900	$200,000.00
July 1, 1900, balance unexpended	200,000.00
July 1, 1900, balance available	200,000.00
Amount (estimated) required for completion of English system	2,261,338.00
Amount (estimated) required for completion of American system	881,377.00
Amount that can be profitably expended in fiscal year ending June 30, 1902, if English system be adopted, in addition to the balance available July 1, 1900	1,308,463.00
Amount that can be profitably expended in fiscal year ending June 30, 1902, if American system be adopted, in addition to the balance available July 1, 1900	500,000.00

APPENDIX H H H.

IMPROVEMENT AND CARE OF PUBLIC BUILDINGS AND GROUNDS IN THE DISTRICT OF COLUMBIA—WASHINGTON MONUMENT.

REPORT OF COL. THEO. A. BINGHAM, UNITED STATES ARMY, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1900.

OFFICE OF PUBLIC BUILDINGS AND GROUNDS,
Washington, D. C., July 19, 1900.

GENERAL: I have the honor to submit the following report of operations upon public buildings and grounds in the District of Columbia, under the Chief of Engineers, during the fiscal year ending June 30, 1900:

In addition to the public buildings and grounds, this office has also been charged with the care and repair of the Government telegraph lines connecting the Capitol with the various Departments and the Government Printing Office; of the repair and improvement of the Government Printing Office; of the repair of the building on Tenth street NW. where Abraham Lincoln died; of the construction of the statue of Gen. John A. Logan; of such matters connected with the erection of the statue of General Sherman as may properly devolve upon the War Department; of the monument at Wakefield, Va., the birthplace of Washington, and the iron-pile dock erected under the supervision of this office in 1894, under the direction of the Department of State, at the mouth of Bridge Creek, Virginia; of the erection in the national military park at Gettysburg, Pa., of the memorial tablet to Abraham Lincoln; of the preservation, care, and safety of buildings occupied by the War Department in the District of Columbia, except State, War, and Navy Department building; of the banks of the Potomac River from the north line of the Arsenal grounds to the southern curb line of N street; since June 15, 1900, of the work of continuing plans for extending the Executive Mansion; and since June 20, 1900, of the work of making on examination and reporting plans for the treatment of that section of the District of Columbia situated south of Pennsylvania avenue and north of B street SW., and for a suitable connection between the Potomac and Zoological parks.

PUBLIC BUILDINGS.

EXECUTIVE MANSION, GREENHOUSES, CONSERVATORY, AND STABLES.

Care, repair, and refurnishing.—The usual care was given to the Mansion and its furniture. Repairs were made to furniture, and some new furnishings, linen, silverware, and glassware purchased. In Octo-

ber, 1899, all carpets were relaid, lace curtains, window draperies, and door portiers hung, and the house placed in order for the winter. The awnings were removed from the windows in the autumn and replaced in the spring. In May, 1900, the carpets were taken up, cleaned, and stored, the lace curtains and draperies removed from the windows, the laces laundered, the draperies cleaned, and all packed away for the summer. Floor matting was carefully gone over and carpet linings cleaned. Eight mattresses were made over and slip covers provided for four of them. One thousand yards of new straw matting was purchased to replace such as had become worn out and unserviceable. The five large awnings on south portico were relined with new material. A silver polishing apparatus operated by an electric motor was purchased and placed in position in the engine room in basement. The old steam boiler, electric pump, motor, pipes, etc., in engine room were cleaned, and repainted where necessary. The elevator and operating machinery were cleaned and maintained in good working order. New doorsills were put down where required, minor repairs made to woodwork, and window sashes eased and repaired. Stair balustrades cleaned and polished, new slat doors placed at entrances to three storerooms under north portico, and a new hand rail put in place on stairway from west end of first floor corridor to basement. A rope ladder was purchased and placed in a box on the roof for use in case of fire. Some old carpets, matting, furniture, etc., were sold by the steward at public auction on December 20, 1899, and the proceeds, $1,251.75, turned into the Treasury.

Painting and glazing.—The woodwork in the following apartments has been painted: Basement corridor and parts of stairways therefrom, two kitchens, laundry and two rooms adjoining, billiard room, servants' bathroom, filter room, and three small rooms, all in basement. The elevator car and the elevator halls on first and second floors touched up and varnished, and a new glass placed in top of car. Some of the woodwork in the entrance vestibule touched up and varnished; the two front doors scraped, oiled, and varnished, and the radiators and guards of same in vestibule painted and bronzed. Partitions, doors, door frames, and washboards in engine room and passage thereto, windows, doors, door frames, and gates under north portico, and all woodwork outside of west basement door painted. Sixteen storm window sash painted, and reglazed where required. The plain glass in the upper sash of eight basement windows on the north front was taken out and replaced with ground glass. The iron guards at basement windows, the woodwork and ironwork of forty-three window screens, two slat doors, and two lamp-posts and lamps at east front were painted; some necessary painting done about the north and south porticos, some minor miscellaneous painting done, and broken window glass replaced with new glass.

Electric work, lighting, and plumbing.—The electric light and power overhead cables were taken down and placed in the new concrete tunnel constructed last year. The large main switches have been placed in the motor room, using that room as a center of distribution. The mains supplying the conservatory on the east and west ends were extended to the tunnel and connected with the new cables and a casing constructed around them to prevent injury. Additional wires were also run to supply lights to the rooms under the conservatory. In making the foregoing changes the carrying capacity of the cables has

THE EXECUTIVE MANSION IN 1900. NORTH SIDE.

THE EXECUTIVE MANSION IN 1900. SOUTH SIDE.

been increased by the addition of copper, making allowance for increase in load in the future, so that the lighting lines have had added to them an additional safe carrying capacity of about 200 amperes, and the power lines about 32 amperes. All the electric light, power, telegraph, and telephone wires serving the Mansion are now underground. The motor room was cleaned and repainted throughout, including the elevator machinery and appliances. Two additional outlets were placed in ceiling of main corridor first floor to furnish additional lights for the ends of corridor on occasions of official functions. Three additional electric lights were placed in the pink bedroom. An electric bell connection was made between the corridor on the second floor and the butler's pantry, first floor, and between the north front door and the attic. The three silver and crystal chandeliers in the East Room, four in corridor first floor, and two in State dining room, nine in all, were taken down, taken apart, all the metal parts replated, and the chandeliers put together again, rewired for the electric lights, and rehung. The metal parts of the gilt chandelier in the Blue Parlor were also replated and the chandelier rewired and rehung. All the crystal on chandeliers was removed, cleaned, and replaced, and all other chandeliers and brackets cleaned. Necessary attention was paid to the plumbing, lighting, and heating arrangements, and they were maintained in good order. Some improvements were made in toilet room in northeast corner room. An additional line of 10-inch cast-iron pipe was laid in the concrete tunnel for draining the north area way and the large fountain basin at the north front. The length of this additional line is 195 feet.

Telephone wires.—In October, 1899, about 1,500 feet of old six-wire lead-covered cable which had been stored at the property yard of Public Buildings and Grounds was tested and spliced and run in three sections through the underground conduit between the Mansion and the State, War, and Navy Department building for the use of the automatic telephone service between those buildings, replacing the aerial cables which formerly made part of the connection; 75 feet of 2 by 2 conduit were constructed in the basement of the Mansion for this service; all the necessary inside connections made, and the old overhead cables and wires taken down. In March, 1900, 115 feet of this cable was found to be unserviceable and was replaced with another length of cable. In April, 1900, all of this old cable was found to be so defective, owing to poor insulation, as to be practically useless, and it was accordingly removed and replaced with a new lead-covered cable 530 feet in length, containing 15 wires, and all necessary connections made.

Receptions.—The exit bridge used at the north front on occasions of official receptions was repaired and repainted. New canvas canopies were made and fitted to the old iron frames for use at the north and south fronts, and some new cocoa matting and linen floor crash purchased. New velour curtains, with necessary supporting standards, were purchased for screening off a portion of the private dining room for use as a passageway for guests at receptions. Some of the cloak boxes were put up, and the east room, parlors, and lower corridor were decorated with plants for a reception in September and one in November, 1899, and the same apartments and the state dining room were similarly decorated for a state dinner in October. The canopies, exit bridge, and storm doors were erected for the reception on New Year's day. The exit bridge, storm doors, canopies, cloak boxes, and

screen curtains were placed in position for three official receptions in January and two in February, and the east room, parlors, and lower corridor beautifully decorated with plants and flowers for those functions and for three state dinners given in those months. Similar preparations, omitting the cloak boxes and some of the floral decorations, were also made for a reception given in May and one in June, and linen floor crash was laid in parlors and state dining room for use at a reception in April.

East room.—Part of the woodwork of nine windows, the washboards, and four door frames were painted and the gilt work bronzed where necessary. All the glass disks on the ceiling, which cover electric lamps, were taken down, cleaned, new lamps put up, and the disks replaced. New electric lamps were also placed on the chandeliers. Loose linen covers were purchased and placed on the furniture—29 pieces in all.

The eastern or green parlor.—One mirror stand and the frames of the two large mirrors were regilded. Loose covers of white dimity were purchased and placed upon the sofa and center divan.

The middle or blue parlor.—This apartment has been redecorated and refurnished, the work having been completed in September, 1899. The old cornice was removed and replaced with a new cornice containing a cove, into which electric lamps were placed to more perfectly illuminate the ceiling. The ceiling and walls were redecorated, new silk being placed on the latter between the frieze and dado and finished in panel effects. The woodwork of the room was repainted and two new mirrors placed, one over the mantel of fireplace on east side and the other on a console table on west side, the old mirrors removed from the room being utilized in another apartment. The frames of the furniture were regilded and the furniture reupholstered and re-covered with new silk damask to match that in the panels on the walls. New window and door draperies and new lace curtains were hung and new straw matting and a new carpet laid. In the spring of 1900 new loose covers of white pique were made and placed upon the furniture and new sateen covers of a light-blue shade placed over the damask on the walls to prevent fading.

State dining room.—The frames of the three large mirrors were regilded, the window grills repainted and rebronzed, and the woodwork repainted. A solid walnut top was made and placed on sideboard. Thirty dining chairs were braced and new mahogany arms placed on them. Five large fruit baskets and four large candelabra were repaired and regilded. Five pairs of new lace curtains were purchased for the windows.

Private dining room.—The woodwork was repainted and the swing doors at doorway to butler's pantry were re-covered with leather and rehung with new hinges. New straw matting and a new Wilton carpet were laid, new carpet rugs furnished, new window draperies made and hung, and a new drapery placed on the mantel. Two large mirrors were removed from the blue parlor, their frames repaired and regilded, and the mirrors hung in this room.

Butler's pantry.—The woodwork, ceiling, and walls were repainted, two tables stained and varnished, tables and window sills covered with white enameled cloth, and the floor covered with new linoleum.

Corridor, first floor.—Floor matting was rebound, and mirror frames and cabinets cleaned and touched up with stain and varnish where

THE EXECUTIVE MANSION IN 1900. EAST SIDE.

necessary. New silk heavy tapestry was purchased for re-covering the furniture in the main part of the corridor. The ceiling of the elevator hall opening from this corridor was repapered.

Library.—New base molding and carpet sills were put down, the side walls repapered, and the ceiling frescoed. Three sofas and eleven chairs were reupholstered where necessary and re-covered with new materials, new lace curtains and new silk draperies placed at the windows, and new straw matting laid on the floor. The bookcases were cleaned and new silk curtains placed inside their doors. New loose covers of dimity were made and placed upon the furniture.

The south or red bedroom.—New base molding and carpet sills were put in place, the walls and ceiling repapered, and the woodwork, cornice, and centerpiece painted. The frame of large mirror was regilded, two new easy chairs and three new side chairs purchased, new bed draperies made, two chairs and one couch reupholstered and re-covered, and all of the cabinet furniture scraped and refinished. A new Brussels carpet was laid, a pair of new laces furnished for bed canopy, new silk window draperies hung, and new window awnings put up.

The southwest or green bedroom.—The room was repapered, cornice and frieze retinted, and a new shoe molding placed around base of washboards. The furniture was cleaned and new awnings placed at the windows.

Southwest bathroom.—The walls, ceiling, and woodwork were repainted and the chandelier rehung.

Northwest dressing room.—New sashes with plate glass were put in the three windows, the window frames painted, and new matting laid on the floor. The paper on wall of bathroom in this apartment was removed, the wall painted, and the woodwork touched up and varnished.

Northwest or blue bedroom.—New sashes with plate glass were put in the two windows and the window frames painted. Some of the woodwork was repainted and the ceiling retinted. Two couches, four chairs, and two window seats were re-covered with new material, and new linen loose covers made and placed upon them. Four chairs were refinished, the cabinet furniture cleaned, and new table covers and draperies for doors and cabinet made.

North bathroom.—New sash with plate glass were put in the window and the window frame painted. One of the bath tubs which had become worn was removed and replaced with a new and shorter tub and a marble washstand put in.

The north middle blue bedroom.—A new Brussels carpet was laid, a new mahogany washstand purchased, new window draperies, door portieres, and a new loose cover for mantel made, and two armchairs and one lounge reupholstered where necessary and re-covered.

Corridor, second floor.—The old dark paint on the washboards and window and door frames was burned off, and they were repainted in light-cream color and the doors refinished; the walls and cornices were repainted, the ceilings scraped and repapered, decayed wood replaced with new, and new doorsills put down where necessary. A new middle sash was placed in the window at the west end and new silk drapery placed at this window. Two sofas and two armchairs were reupholstered and re-covered with new materials, the cushions used in the corridor re-covered with new materials, and loose covers of dimity made for the furniture. A new Wilton velvet carpet was laid the entire

length of the corridor, and similar carpet was also laid upon the floor of the elevator hall opening from the corridor.

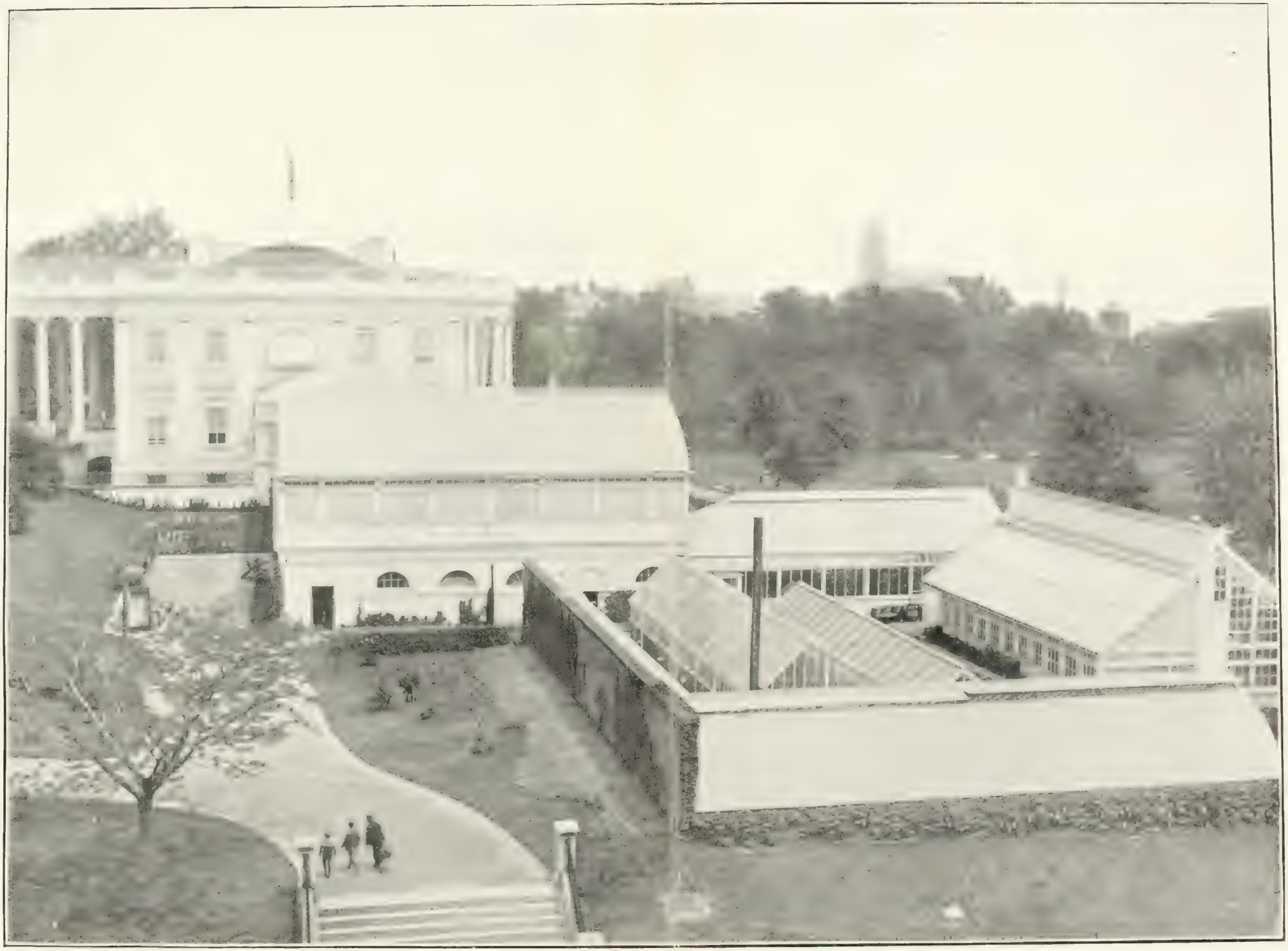
Cabinet room.—The ceiling, walls, cornice, and woodwork were repainted, the door revarnished, and the furniture cleaned.

Executive office rooms.—The floor of the large office room on the north front having settled in consequence of the great weight imposed upon it by the increasing records and cases for holding them, all of the heavy bookcases and books were removed from the room and the office waiting room adjoining to the basement floor, a portion of the larger books being stored in the attic and basement. The walls and ceiling of the room were then repapered and the cornice cleaned off and retinted. The painted ceiling of the office waiting room was also touched up.

Greenhouses, Executive Mansion.—Necessary repairs were made to the woodwork in the houses, all repaired work painted, broken glass replaced with new glass, boilers, flues, and pipes of heating apparatus cleaned out and repaired, and the boilers and pipes painted with asphaltum. The interior of the head gardener's office was wainscoted, repapered, and repainted, new closets and locker constructed, and the exterior of the building painted. The exterior and interior of the small rose house, of the camelia house, and of the grapery were repainted, and some miscellaneous painting done. Portions of the glass roofs were shaded with white paint during the extreme hot weather to protect the plants from the rays of the sun. The usual care was extended to the large collection of plants, and greenhouse flowering plants and bedding plants for the ornamentation of the grounds were propagated and 13,850 bulbs purchased under contract for forcing in the houses and for planting in the grounds for early spring bloom. In July the flowering bulbs removed from the beds in the grounds in the spring, numbering over 59,000, were cleaned and stored for future use.

Conservatory, Executive Mansion.—Repairs were made to the old wooden superstructure, the work consisting of putting in some new rafters, posts, wall plate, facia on benches, casing, sills, sash rims, molding, transoms, side sash, roof sash, and sash bars. The interior and exterior of the superstructure were repainted and all broken glass replaced with new glass. The windows and doors of the rooms and passages of the stone substructure of the building, the outside of coal bins and the doors to all closets and lockers were also painted, and necessary repairs made to the pot bins and the tool and material closets. Glass in the roof and east, south, and west sides of the superstructure was shaded with white paint during the hot months.

Stables, Executive Mansion.—Extensive repairs have been made to this building. Seven of the old iron stall posts were removed and one reset, the old flooring removed from three box stalls and four single stalls and replaced with new flooring. One box stall was converted into two single stalls. Wire guards were placed on the stall partitions, two new window guards put up, and a new door with an iron guard on top placed on each of three box stalls. Old casing around windows was torn out and replaced with new material and iron wainscot cap put on all corners to protect them from rubbing. Twelve feed troughs were reset, new casing placed around doorways, and a sliding door altered and rollers placed on same. Pipe for draining the gutters at foot of stalls and water pipe and an automatic flush tank for flushing



THE EXECUTIVE MANSION IN 1900. WEST SIDE.

THE EXECUTIVE MANSION IN 1900. PANORAMIC VIEW FROM ROOF, LOOKING SOUTHWEST.

them were put in position. The old water-closet in the cellar was torn out and replaced with a new one, a new urinal put in, an iron flush tank replaced with one of wood, copper lined, and all of the old pipe in place in the cellar, the use of which had been discontinued, removed. The gas fixtures throughout the building were overhauled and new burners put on. Joints in the flooring of sixteen stalls were calked, two cupboards constructed, and blanket poles put up. The hayracks in the north side were taken out and stored in the loft. Repairs were made to the slate roof of the building. All of the repaired woodwork, the interior walls as high as top of stall guards, and the inside and outside of the windows in east end on first floor were painted, and all broken glass in the windows replaced with new glass. The old tin was removed from the roof over the courtyard between the carriage houses and an entire new tin roof covering put on, old sheathing being replaced with new where needed. Two additional skylights were placed in this roof, five window sills covered with new tin, and new gutters and down spouts of galvanized iron were placed around the entire building. The new tin roof, the gutters and spouts, and the iron fence in front of the building were painted.

Stable, public buildings and grounds.—Necessary repairs and an extension were made to this building, which stands in the rear of the stable of the Executive Mansion. The small wagon house at northwest corner of the stable was moved 10 feet west and placed on stone piers and an extension to the stable built over the space thus vacated. In the old part of the building the old floors in six stalls were removed and replaced with sound material. A new girder and new joists were placed under the stalls. Ceilings and sides of stalls were sheathed, new troughs made, windows replaced at ends of five stalls, a trapdoor placed at east end of the stable, and one side of the hayloft sheathed. One new stall was made and the back of two stalls cased up. A new double floor for use in washing vehicles was constructed in the carriage house, two windows closed, some new washboards put in, and a small cupboard constructed. The platform at the entrance to stable was repaired and enlarged and the ground at the back of the building graded. Slight repairs were made to the plumbing and to the roof, new tin gutters placed in position, the exterior of the building and the gutters and down spouts painted, broken glass replaced with new glass, and some necessary painting done in the interior of the building.

WASHINGTON NATIONAL MONUMENT.

The usual care has been extended to maintain the Monument and its machinery in good condition and to keep the interior of the shaft clean. Only three arrests were made during the year of persons who were detected in defacing the Monument.

The elevator and all machinery connected therewith have been carefully inspected each month by an agent of the builders and pronounced in good and safe condition. Weekly inspections are also made by the steam engineers at the Monument, and tests of the safety appliances on the elevator car are made daily by the employees before starting to carry passengers to the top.

The operation of the machinery was suspended once each quarter, the boilers washed out, examined, and tested with cold-water pressure, and necessary repairs made to furnaces, steam pipes, and connections.

To permit of these examinations and repairs the machinery was shut down from September 26 to 30, and December 26 to 28, 1899, and from March 26 to 29 and June 25 to 28, 1900, all inclusive. The machinery was also shut down on July 1, 1899, in order to permit of the placing of a new ell on the main steam pipe in tunnel between the boiler house and engine room in place of one that had burst.

Necessary repairs were made in the elevator engines, 42 feet of the main steam pipe covered with cork covering and 16 feet of the pipe wound with jute and painted with asphaltum. New joints were made on this main steam pipe as required. The roof of the engine room was repaired and painted, the handrail around same, the doors, window sash, and casing, and the covering on steam pipes were also painted and the walls of the area around the room whitewashed. The fronts of the boilers and the steam pipes were painted with asphaltum, and the interior walls of the boiler house whitewashed.

The channel irons which were placed on the tie-rods of the iron framework in the monument to stiffen them, and the interior and exterior of the elevator cars, the woodwork around the windows at top, and the wire screen or guard at the 490-foot landing have been painted. Two iron plates or safety guards have been placed on step of elevator car, one at each end, to prevent a person from being pushed off while entering or leaving the car at the top landing. The old telephones in the car, engine room, boiler house, and lodge house have been replaced with new instruments. Two self-recording thermometers for recording the fluctuations in temperature during the twenty-four hours of each day have been placed—one on the top floor and the other on bottom floor—making 4 of these instruments now at the monument, the other 2 being on the outside at the bottom, one on north face and the other on the south face. The two which had been placed on the outside face at the top have been taken down, as it was found that the stone was being stained from the brass of which they are made.

The electric-light plant has been maintained in good condition, and repairs made to engine and dynamos as required. New tap wires have been run from the main wire to the electric lamps from the bottom to the 380-foot landing; 1,800 feet of new wire and 46 new porcelain receptacles having been used for the purpose.

At the lodge house repairs have been made to the metal-roof covering, the roof, windows, sashes, casing in boiler pit, and floors in office room and waiting room painted, and those floors and the outside doors given a coat of hard-oil finish. The lead of steam supply and drain pipes between boiler and radiators has been changed so as to give better drainage from the radiators, and the location of the steam radiator in the office room changed so as to more perfectly warm the room.

During an electrical storm on July 13, 1899, lightning struck the monument. The fluid followed the conducting columns in the interior of the shaft down to the 50-foot landing, where it left the northwest column, struck the floor plates in rear of elevator, and exploded; thence into the engine room on the pipes or wires, where the only damage done was the burning out of the magneto coil of the telephone, which broke the connection between the engine room and the boiler house. It is a coincidence that each time the monument has been struck by lightning the fluid has left the columns about the same place.

During this storm the lightning also went into the lodge house on the telephone wires and burnt out the magneto coil of the telephone.

Again, during an electrical storm on the afternoon of May 3, 1900, a man who was standing on the lower floor of the monument and leaning against one of the iron columns which support the stairways received quite a heavy shock of electricity in his arm and shoulder, and two men who were looking out of one of the windows at the top at the same time reported that the flash seemed to come in the window over their heads. They were blinded for a moment. No damage was done. The iron columns referred to act as lightning conductors, the lightning rods on the outside of the pyramidian being connected with them for that purpose.

On January 8, 1900, so much steam was found to be escaping in the engine room that it was deemed best to shut down the machinery for investigation. An examination of the elevator engine, which was in use during the entire time of the reconstruction of the monument for the hoisting of material, showed that it was practically worn out, and a special report as to its condition was made to the Chief of Engineers by letter of January 20, from this office, with the recommendation that an estimate, amounting to $26,500, for replacing the present system by an electric installation, be submitted to Congress as a special estimate for the ensuing fiscal year, as suggested in the annual report of this office for 1899 (page 3819). In order to keep the elevator running for the accommodation of the constant crowd of visitors, necessary repairs were immediately made to the old engine. This necessitated the stopping of the elevator from January 11 to 24, inclusive, during which period visitors were compelled to make the ascent of the shaft by the stairway.

The following table shows the number of visitors to the top of the monument each month, both by the elevator and stairway, the total number during the year, and the aggregate number since the shaft was opened to the public, October 9, 1888:

Month.	Number by the elevator.	Number by the stairway.	Total.	Aggregate since Oct. 9, 1888.
1899.				
July	8,430	2,701	11,131	1,707,849
August	11,735	2,900	14,635	1,722,484
September	10,552	11,796	22,348	1,744,832
October	10,007	7,000	17,007	1,761,839
November	7,767	1,410	9,177	1,771,016
December	7,338	3,515	10,853	1,781,869
1900.				
January	4,395	3,435	7,830	1,789,699
February	7,417	1,888	9,305	1,799,004
March	7,159	2,403	9,562	1,808,566
April	11,797	6,520	18,317	1,826,883
May	12,024	5,728	17,752	1,844,635
June	9,867	5,330	15,197	1,859,832
Total	108,488	54,626	163,114	....

ELECTRIC ELEVATOR FOR THE MONUMENT.

By (sundry civil) act approved June 6, 1900, $26,500 were appropriated for replacing the steam elevator at the monument by an electric one, and preliminary plans have been made and a project submitted and approved. It is hoped to complete the change much before the end of another fiscal year.

LEVELS AT WASHINGTON MONUMENT.

Bench mark, to which levels are referred, was established by the Coast and Geodetic Survey in April, 1899, and is 29.632 feet above mean sea level.

Elevations of bench marks at corners of monument above mean level.

Date.	Northwest.	Northeast.	Southwest.	Southeast.	Remarks.
May 19, 1898	40.776	40.815	40.776	40.815	
May 4, 1899	40.755	40.756	40.760	40.760	Weather fair; seeing good.
June 5, 1899	40.722	40.739	40.724	40.727	Very warm; seeing poor.
July 5, 1899	40.768	40.757	40.755	40.762	Weather fair; seeing fair.
Aug. 9, 1899	40.752	40.758	40.755	40.765	Levels taken in cool of evening.
Sept. 7, 1899	40.759	40.756	40.757	40.761	Do.
October, 1899	....	....	....	....	No levels taken this month.
Nov. 2, 1899	40.750	40.742	40.752	40.753	Seeing good; weather cool.
Dec. 9, 1899	40.751	40.754	40.764	40.770	Do.
Jan. 12, 1900	40.754	40.755	40.765	40.765	Fresh northwest wind; seeing fair.
Feb. 10, 1900	40.752	40.756	40.752	40.763	Cloudy and cold; seeing fair.
Mar. 23, 1900	40.769	40.768	40.768	40.771	Fresh southwest wind; seeing fair.
Apr. 23, 1900	40.762	40.769	40.769	40.764	Turned very warm after rain; seeing poor.
May 17, 1900	40.760	40.762	40.761	40.759	Very warm; seeing poor.
June 13, 1900	40.760	40.754	40.759	40.758	Cloudy but warm; seeing good.

BUILDINGS OCCUPIED AS OFFICES BY THE WAR DEPARTMENT, EXCEPT STATE, WAR, AND NAVY DEPARTMENTS BUILDING.

Under date of June 30, 1893, these buildings were placed under the charge of this office, so far as their preservation, care, and safety are concerned. They now consist of twelve buildings, as follows:

Army Medical Museum and Library, Seventh and B streets SW.

Ford's Theater building, 511 Tenth street NW.

Annex to Ford's Theater building, 509 Tenth street NW.

No. 610 Seventeenth street NW., Record and Pension Office.

Southwest corner of Seventeenth and F streets NW., office of depot quartermaster, United States Army.

No. 1725 F street NW., branch printing office, War Department.

No. 1712 G street NW., Rebellion Record Office.

No. 1744 G street NW., Ordnance and Pay Departments, United States Army.

No. 1814 G street NW., Medical Department, United States Army.

Annex to Winder Building, Ordnance Department, United States Army.

War Department stables, G street, between Seventeenth and Eighteenth streets NW.

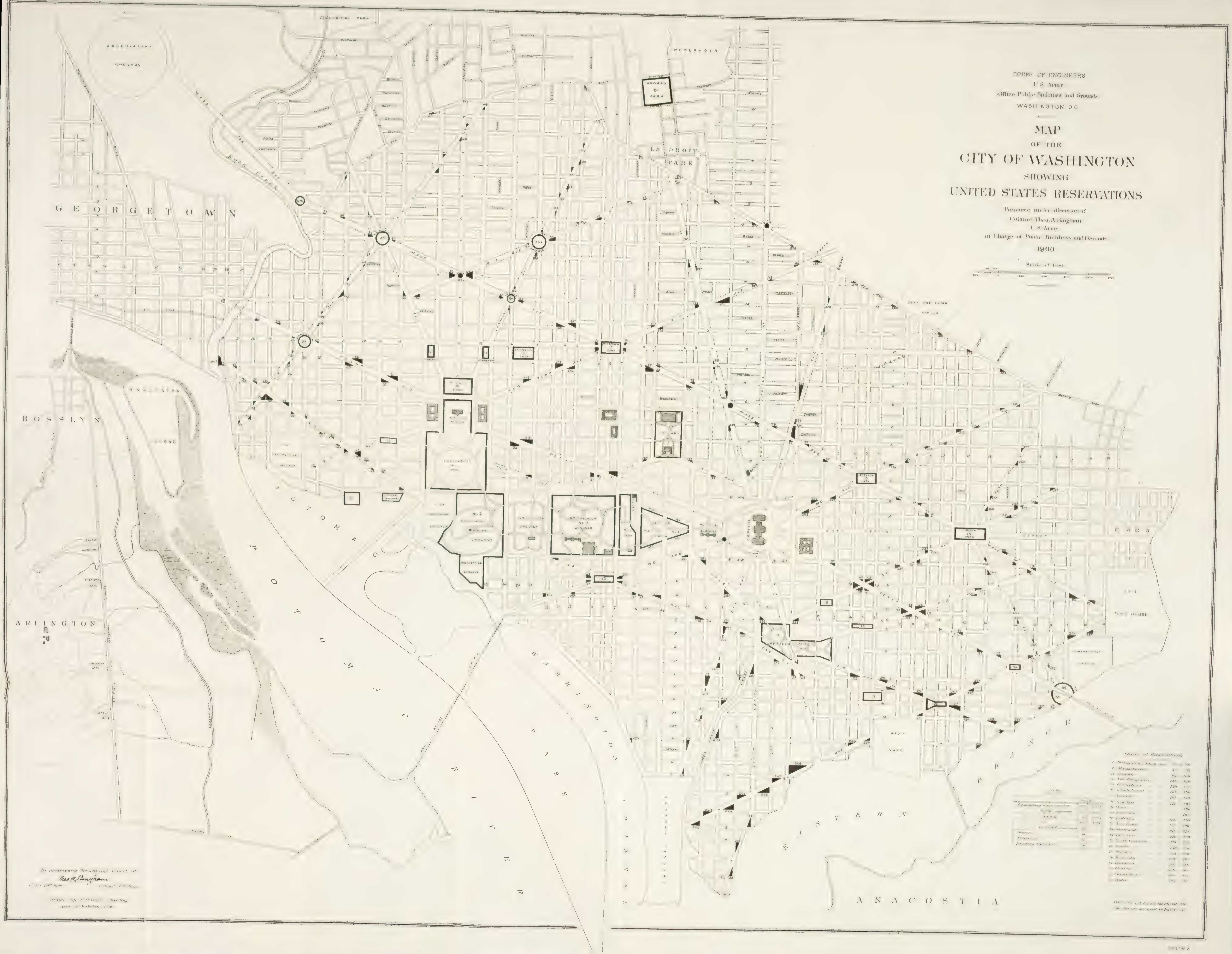
Lemon Building, No. 1729 New York avenue NW., occupied by Supply Division, War Department, etc.

Monthly inspections have been made of these buildings during the year, and they are believed to be in good and safe condition for the purposes for which they are being used.

HOUSE NO. 516 TENTH STREET NW., WHERE ABRAHAM LINCOLN DIED.

This property was purchased by the United States in November 1896, since which date it has been under the supervision of this office.

In the sundry civil act approved March 3, 1899, Congress appropriated \$3,833.50 for the repair of the building, and during the fiscal year



CORPS OF ENGINEERS
U. S. Army
Office Public Buildings and Grounds
WASHINGTON, D.C.
MAP
OF THE
CITY OF WASHINGTON
SHOWING
UNITED STATES RESERVATIONS
Prepared under direction of
Colonel Theo. A. Bingham
U. S. Army
In Charge of Public Buildings and Grounds
1900
Scale of feet
GEORGETOWN
ROSSLYN
ARLINGTON
POTOMAC
POTOMAC RIVER
WASHINGTON PARK
EASTERN
BRANCH
ANACOSTIA
LE DROIT PARK
HOWARD 20 PARK
RESERVOIR
ZOOLOGICAL PARK
CAPITOL
GARFIELD PARK
NAVY YARD
Theo. A. Bingham

ending June 30, 1900, it has been thoroughly overhauled and put in good repair, repapered, repainted, furnished with steam heat, a waterproof course inserted in the walls of the main building, brick addition built in rear which furnishes a fuel shed on the ground floor, and an additional room on the second story, new plumbing installed, and gas pipes and fixtures overhauled and put in good order.

By authority of the Secretary of War, dated October 9, 1899, Mr. O. H. Oldroyd is allowed to occupy this building, with his family, as custodian without pay, and to exhibit his Lincoln Museum and to charge a small entrance fee therefor.

IMPROVEMENT OF THE PUBLIC GROUNDS IN THE DISTRICT OF COLUMBIA.

VARIOUS RESERVATIONS.

The area covered by the park spaces in the District of Columbia under charge of this office is 407.21 acres.

There are in all 302 reservations, varying in size from 250 square feet to 82 acres.

By authority of section 5, act approved July 1, 1898 (Stat., vol. 30, p. 570), two circular reservations were added to the charge of this office April 7, 1900, comprising three-fourths of an acre in all. One is at the intersection of Massachusetts avenue and Twenty-third street NW., and the other at the intersection of North Capitol street and Florida avenue.

These reservations are classified as follows:

	Number.	Acres.
Highly improved	106	353.03
Partially improved	53	23.04
Unimproved	143	31.14
Total	302	407.21

Of these, 9 have granite coping, 94 have open, low, iron post and chain fences; 22 provided with marking stones only, and 178 have no delimiting marks.

Between June 30, 1899, and June 30, 1900, the $10,000 extra appropriated by Congress was used for improving 21 reservations, comprising 8.5 acres in various parts of the city, as shown on the accompanying map, leaving something less than $1,000 for maintenance. The improvement consisted in marking by stones, grading, introducing water, covering with soil (beginning), sowing with grass seed, and in some cases inclosing with iron post and chain fences.

The same amount having been continued by the last Congress, it is hoped to make equally good progress next year.

COST OF COMPLETING IMPROVEMENT OF REMAINING UNIMPROVED PARKS IN WASHINGTON.

The Annual Report of my predecessor for 1893 outlines a general plan for the development of park improvement. My report for 1899 discusses:

(*a*) General treatment of parks in Washington.
(*b*) The parks of Washington in relation to those of other cities.
(*c*) The future of parks in Washington.

There are still about 145 unimproved reservations in the charge of this office. An average of $600 apiece would make a good beginning toward making parks of them. An average of $1,000 apiece would make them fairly presentable.

In other words, at the present rate of appropriations for improving new grounds $87,000 will bring all the park spaces now under this office to the first stage of improvement, and will take about nine years.

It would take $145,000 to put all the unimproved parks under this office into very presentable shape, requiring at the present rate fourteen and a half years. But $50,000 per year could be spent advantageously, and this would practically finish up this preliminary work in three years. Of course the facilities of the nursery and propagating gardens would have to be increased and three subdepots established. But if the work were undertaken on the scale suggested and pushed through in three years enough could be saved to provide for these also.

This suggestion for accomplishing this preliminary park work is presented as the most business-like method of getting the work done.

In this connection a table is presented showing money spent on parks in various large cities throughout the country during the past ten years. Attention is called to the very large amounts spent by the large cities, and the proportionately large sums spent by cities of the size of Washington as compared with the amounts available for Washington during the same period.

MAINTENANCE OF PARKS IN WASHINGTON.

The grounds of the Executive Mansion (18.5 acres) have the most care of any park in Washington. The average annual cost of maintenance is $8,750, or $473 per acre. The use which they necessarily get prevents as great perfection as might be otherwise had, yet they are, on the whole, apparently satisfactory to the people.

President's Park, adjoining, contains 63.7 acres, and has an annual average expenditure of $4,000, or $62.80 per acre. As might be expected, it is impossible to keep it up more than passably.

The Monument grounds (Washington Park) contains 78.5 acres, and have an average annual expenditure of $3,000, or $38.20 per acre.

Smithsonian grounds contain 58.02 acres, and have an annual average expenditure of $2,500, or $43 per acre.

Garfield Park has 23.98 acres, and an annual average of $3,000, or $124 per acre.

Ordinary simple maintenance (only) of a fair degree is commonly estimated at $300 per acre per annum. This office has 400 acres. Hence, according to the figures ordinarily used, $120,000 per year should be estimated for maintenance only. Only about $72,000 per year is actually expended, but the results, while exceedingly good for the money, are not satisfactory artistically.

COST OF PARKS IN GENERAL.

This falls under three heads, viz: (*a*) Purchase of the land; (*b*) Improvement; (*c*) Maintenance. The first depends, of course, on the depth of the municipal pocket, and here let it not be forgotten that generous parks bring in large returns in the better health of the population and reduction of the death rate; in providing pleasure grounds for young and old; in improving real estate values; in refining and

Data relating to principal city parks in the United States.

	Name of city.	Population.		Spent on parks 1889-1899.			Total.	Area of parks, 1897.	Annual cost of maintenance, 1897.	Cost of maintenance per acre, 1897.	Average annual amount for improvement, 1897.	Cost of improvement per acre, 1897.	Salary paid to chief park engineer per annum, 1897.	Remarks.
		1890.	1900 estimate.	Purchase of land.	Improvements.	Maintenance.								
								Acres.						
1	Albany, N. Y							Maintain ... 175 Control ... 450	$23,000.00	$131.42	(a)	(a)	$3,000.00	
2	Baltimore, Md							1,103	124,800.00	113.15	$55,770.00	$50.56	3,000.00	
3	Boston, Mass	448,477	560,504	$3,752,263.55	$5,314,659.53	$996,438.78	$10,063,361.86	2,191	125,000.00	b 57.05	450,000.00	205.38	3,600.00	
4	Brooklyn, N. Y							1,700	500,000.00	294.11	c 200,000.00 d 250,000.00	264.70	3,500.00	Superintendent.
5	Buffalo, N. Y	255,664	393,600	237,175.00		2,136,397.00	2,373,572.00							
6	Chicago, Ill	1,268,669	1,950,000				e 16,171,188.85	Lincoln ... 310 Boulevard. 89.5 South ... 1,181.33 West C ... 600 Boulevard. 375 464.5 2,091.93	181,295.37 5,196.70 330,000.00 325,000.00	584.82 58.06 279.34 333.33	67,300.35 98,073.18 100,000.00 250,000.00	217.10 1,095.79 84.64 256.41	1,500.00 3,000.00 5,000.00 3,000.00	Engineer. Superintendent.
7	Cincinnati, Ohio	296,309	360,000				530,000.00	390	f 60,000.00					
8	Cleveland, Ohio							1,223	65,000.00	53.15	2,000,000.00 Lump sum.	1,635.32	3,000.00	
9	Detroit, Mich	205,876	225,000		1,619,084.00	776,271.00	2,395,355.00							
10	Essex County, N. J							3,066	g 2,500,000.00				3,000.00	
11	Indianapolis, Ind							119	13,000.00	109.24	22,000.00	184.70	2,400.00	
12	Kansas City, Mo	132,716	200,000	1,508,042.78		200,489.93	1,708,532.71							
13	Louisville, Ky	201,600	226,680				e 1,158,470.00							
14	Milwaukee, Wis	210,000	300,000				e 1,711,000.00	400 Improved ... 250	35,000.00	140.00	35,000.00	140.00		
15	Minneapolis, Minn			1,000,000.00	360,000.00	100,000.00	1,760,000.00	1,552	50,000.00	32.21	50,000.00	32.21	3,000.00 6.00	Superintendent. Per day for surveyor.
16	New York, N. Y							Total ... 5,186 Central Park ... 575	1,250,000.00	241.03	1,500,000.00	289.24	5,000.00 4,000.00 3,500.00	Landscape architect. Superintendent of parks. Engineer of construction.
17	Omaha, Nebr	139,526	145,000				e 255,000.00							
18	Philadelphia, Pa	1,047,000	1,100,000				h 5,116,928.00	With Fairmount, 3,303 400 acres.	200,000.00	60.55			3,750.00 2,000.00	Chief engineer and superintendent. Landscape gardener.
19	Pittsburg, Pa	238,617	306,000				e 3,800,000.00							
20	San Francisco, Cal	300,000	350,000				2,457,233.00							
21	Savannah, Ga	57,000	67,000				e 93,039.00							
22	St. Louis, Mo	492,224	500,000				e 964,965.00	Forest ... 1,500					1,800.00	General superintendent.
23	St. Paul, Minn	135,000	215,000				e 456,200.00	Nov. 18, 1897 ... 549 Spring, 1898 ... 1,134	22,000.00	40.07	20,000.00	36.43	2,000.00	
24	Toledo, Ohio	91,000	150,000	500,000.00 1897 400,000.00		300,000.00	800,000.00	800	10,000.00	12.50	200,000.00	250.00		
25	Washington, D. C., Off. P. B. & G				93,800.00	633,500.00	727,300.00	405	78,750.00	221.20	i 10,000.00	i 1,176.47	2,000.00	Landscape gardener.

a Bonds issued. *b* For 300 acres. *c* City. *d* County. *e* For all purposes. *f* Including improvements. *g* For acquirement. *h* Fairmount Park only. *i* 1899–1900.

hence making better citizens of all classes, and, by no means least, in establishing a reputation for attractiveness which brings visitors and residents and hard dollars to a city.

COST OF IMPROVEMENT.

It is impossible to give any average figure for cost of improvement. It all depends. The accompanying tabulation collects a few park data from which it will be seen how actual expenses vary. It can be stated, however, that $1,000 per acre on land not too rough nor too thickly wooded will make a fine beginning. If there is much draining or grading or felling to be done, $1,500 per acre, to produce fair results, is not too great an estimate. It is a great advantage and much cheaper to improve large connected tracts of land, rather than small disconnected parks. More curbing or fencing, more fountains, or more detailed care are required to make the latter look well. But the returns are also greater, as in the case of Washington, for instance, where the great number of little parklets spread their advantages among more people than does the one large park of the city. In 1899-1900, 21 unimproved parklets, comprising 8.5 acres, were brought to first stage of improvement in Washington by $8,500, or $1,000 per acre, but these benefits were scattered all over the city, and more people derive advantage therefrom than if double the area had been improved for the same money in one location.

The cost of granite park curbing, like samples shown in annual report of this office for 1899, varies from $2 per linear foot up.

Cost of simple post and chain fences like those common in Washington is about 50 cents per linear foot.

COST OF MAINTENANCE IN GENERAL

is a little more definite. Let us take an example. The area of the grounds of the Executive Mansion inside the fence is 18.48 acres. To keep these grounds in satisfactory order (which is by no means the best possible) would require the following minimum annual estimate solely for the grass, trees, walks, etc.:

1 assistant gardener, at $60	$720
1 foreman, at $60	720
6 laborers, at $1.50 per day	2,880
In addition are required—	
1 horse lawn mower, at $2 per day	625
1 lawn roller, per year (lasts three years—say $15 per annum)	15
6 hand lawn mowers	60
1,000 feet hose	100
Shovels, spades, hoes, rakes, picks, trowels, brooms, trimmers, shears, etc	250
Deterioration of large tools	150
Allow for annual contingencies in the way of necessary lumber, nails, wire, tools, etc	280
We have an annual total of, say, $5,800, or $313.50 per acre, without flower beds.	5,800
For liberal flower beds add—	
1 assistant gardener, at $60	720
Flowers, bulbs, etc., say only $1,500 per annum	1,500
Total	8,020

or $433.50 per acre.

To this must be added the cost of soil, compost, special fertilizers, etc., thus bringing the actual cost annually up to about $600 per acre.

The average annual expenditure of late years has been $8,750, or $473 per acre.

These grounds are kept up as well as any in Washington, but they are used to a considerable extent during a year by the public, and while not in any sense subject to vandalism, are by no means as beautiful as less use and more money would make them.

A perfect grass lawn, for instance, is one of the most delicate fabrics in the world. It must have soil, fertilizers, and seed, weeding, rolling, cutting, and watering, and should rarely be walked over (dusty shoes carry weed germs). Hence a really velvety lawn is rare, and it is easy to see how expensive perfect condition of park grounds must be.

Now take President's Park, south of the Executive Mansion, outside the fence. It contains 63.7 acres. To be well kept up (but not as carefully as the White House grounds) would require the following minimum:

1 foreman, at $2.50 per day	$750
10 laborers, at $1.50 per day, for nine months	3,375
4 laborers, at $1.50 per day, for three months	450
1 horse and driver, at $2 per day	600
1 water cart (lasts three years), per annum	25
1 horse field mower, per annum	25
5 hand lawn mowers	75
1,000 feet hose	100
Proportionate share in cost of running steam road roller, engineer, and coal, say	300
Tools	400
Total	6,100

or a trifle less than $100 per acre.

This is without any flower beds at all, and also without compost, stock for trees, shrubs, etc., and does not include gravel or other material for drives and paths.

For flower beds and that class of work we should allow extra—

2 assistant gardeners, at $60 per month	$1,440
Stock, compost, road material say, only	2,000
Bringing the total to	9,540

or about $150 per acre for a moderate degree of upkeeping.

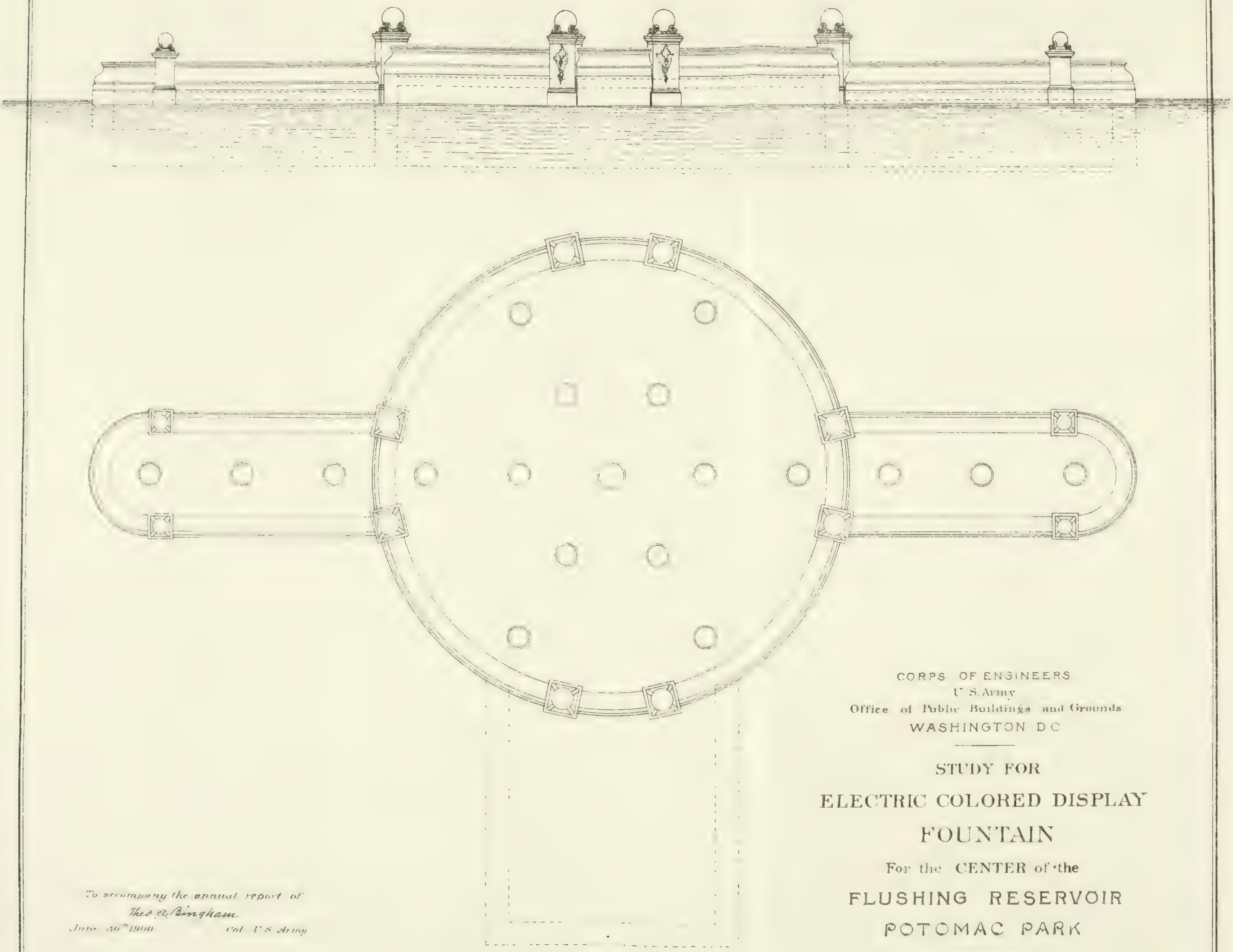
The average annual expenditure for this park is now $4,000, or $62.80 per acre.

The area of the Monument grounds is 78.5 acres. The same estimate as for President's Park is sufficient, viz. $9,540 per year, or, in this case, $121.50 per acre.

The average annual expenditure in this park is $3,000, or $38.20 per acre.

From the above discussion it appears, for Washington at least, that after the necessary plant in the way of nursery, propagating houses, road rollers, and large articles has been provided, maintenance merely can be estimated at from $75 per acre up, according to the degree in which the parks are to be kept; and it is believed that $300 per acre would produce results satisfactory to the most fastidious.

I have been told that at one time, if not now, the street railroads of a large Eastern city paid a tax for their franchise which amounted to 1 cent on every fare, or 20 per cent of gross receipts. This tax was devoted to parks and resulted in making the city at one time famous for them.

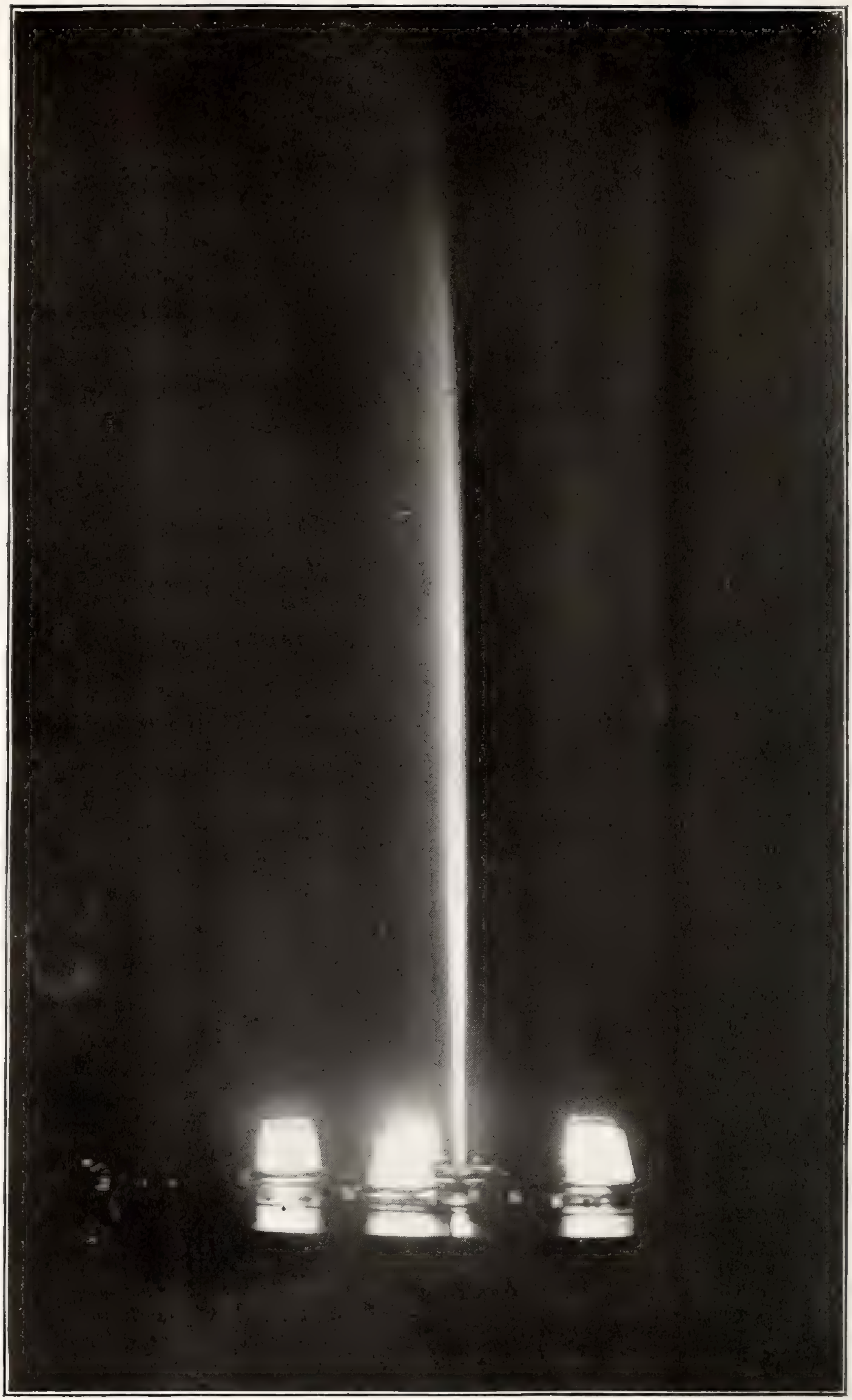


CORPS OF ENGINEERS
U S Army
Office of Public Buildings and Grounds
WASHINGTON D C

STUDY FOR
ELECTRIC COLORED DISPLAY
FOUNTAIN
For the CENTER of the
FLUSHING RESERVOIR
POTOMAC PARK

To accompany the annual report of
Theo. A. Bingham
June 30th 1900 *Col U S Army*

DWG № 447.



ELECTRIC FOUNTAIN. PHOTOGRAPHED BY ITS OWN LIGHT.

ELECTRIC FOUNTAIN: PHOTOGRAPHED BY ITS OWN LIGHT.

FOUNTAINS.

It is remarkable that there are very few fountains in Washington, and these few are insignificant. Not only should the capital have many fountains as an adornment, but they are peculiarly suitable to this subtropical climate. Every circle in the city should really have a large, beautiful fountain, not only from an artistic standpoint, but for the comfort of the inhabitants. A fountain is a rest to mind and body.

Handsome iron fountains of proper size for city use can be had for from $500 up, or, say, $1,000 apiece erected in place. An estimate is submitted for 10 such fountains to be erected in various parts of the city.

There should also be at least one superb electric fountain in Washington which would be worth traveling to see. A very suitable site for it would be the center of the flushing reservoir west of the Monument on the middle line of Seventeenth street. A number of these fountains have been erected in various cities already, and my reports for 1898 and 1899, as well as this one, give illustrations of the effects which can be obtained. There is one in Willow Grove Park, Philadelphia, another in Prospect Park, Brooklyn, and three have been erected this year at the Crystal Palace, London—all American throughout.

The electric power is used not only for illuminating effects, but also to pump the water through the fountain, thus making it independent of the head of water of the city system, and such a fountain located as suggested would obtain its water from the river, and thus be entirely independent of the city supply.

The cost of such a fountain, suitable for Washington, ranges from $25,000 to $40,000.

The boiler house of the Washington Monument could be utilized in establishing such a plant.

PARK CURBING.

It being the wish of Congress that the public parks should be as open as possible, all the former high iron fences have been removed except where absolutely needed. This has left the edges of the parks with an unfinished appearance which, in many cases, is very unsightly.

It has been found by experience that a simple stone curbing gives a pleasing finish, and is sufficient to preserve a neat border line between park and sidewalk. Lafayette Square is an illustration.

Franklin Park, one of the prettiest and most frequented in Washington, suffers for lack of this. A simple but tasteful granite curb can be laid around it for $9,000 or less, and the appropriation of this amount is respectfully urged.

THE MAINTENANCE OF IMPROVED PARKS.

The improved parks and park spaces have been maintained in good condition during the year, the work consisting of mowing and raking lawns, cleaning gutters and drain traps, edging the grassed margins of roads and walks, caring for flower beds, trees, and shrubbery, gathering up and removing rubbish, pruning trees and shrubbery, and sweeping the paved walks through the parks and the pavements around them. Dead and unsightly trees and decaying shrubs have been removed, surfaces of gravel roads and walks repaired, raked, and rolled, board

walks repaired, bare places on lawns seeded and sodded, and new sod laid along the margins of walks, caterpillars removed from trees and elm trees sprayed to destroy the elm beetle, branches of trees overhanging roads and walks removed, drainpipes repaired and freed from stoppages, wire fencing placed around flower beds to protect them, stake and wire fences to prevent trespassing erected, and old fences repaired.

A severe wind storm on the second day of August did considerable damage to the trees in some of the parks, several being entirely destroyed and a large number having branches broken from them.

All the summer bedding plants were removed from the flower beds in the early autumn, some of the beds replanted with chrysanthemums for fall bloom, and others with flowering bulbs and pansies for early spring bloom. In the spring the beds, to the number of 210, were planted with bedding plants for summer decoration.

CHILDREN'S PLAYGROUNDS.

By the act of Congress approved August 30, 1890, the officer in charge of public grounds was authorized to set aside a portion of the public grounds for a children's playground, under regulations to be prescribed by him. The southern portion of the Monument Park was at once set aside for this purpose, but no regulations were prescribed, as there were no means of carrying them out, no watchmen or policemen having been authorized, and the services of the one watchman on duty at the Monument being needed there to protect the structure from acts of vandalism.

Just complaints were received that the lawns were being destroyed, trees injured, and that the children's playground was being overrun by vicious and improper persons. This office has been requested to take action to relieve the grounds of such characters, and has been obliged to call on the District police for assistance.

To protect the improved grounds as far as possible, and to prevent serious annoyance to those enjoying the beauty of the park, the playground was transferred in the autumn of 1893 to the site between B street and the main drive north of the Monument. This plat of ground covers an area of about 8 acres and is occupied nearly all the time by men and boys playing football and baseball.

By the act of Congress approved March 2, 1895, the officer in charge of public buildings and grounds was directed to authorize the use of a portion of the grounds within the ellipse south of the Executive Mansion for a children's playground, under regulations to be prescribed by him.

Notice was given through the public press that children applying would be authorized to play lawn tennis, croquet, cricket, and kindred games. The only requirements were that the children should be recommended by a reputable citizen, and would agree to exercise the common rules of courtesy which would govern them in a private park.

But two requests were received for this privilege. Both were promptly granted, but in neither instance was advantage taken of the permit.

Several applications from young men to play football and baseball in the reservation were received, but it was not believed that it was intended under the law that the lawns of the ellipse or other parks should be used for these purposes.

FOUNTAINS.

It is remarkable that there are very few fountains in Washington, and these few are insignificant. Not only should the capital have many fountains as an adornment, but they are peculiarly suitable to this subtropical climate. Every circle in the city should really have a large, beautiful fountain, not only from an artistic standpoint, but for the comfort of the inhabitants. A fountain is a rest to mind and body.

Handsome iron fountains of proper size for city use can be had for from $500 up, or, say, $1,000 apiece erected in place. An estimate is submitted for 10 such fountains to be erected in various parts of the city.

There should also be at least one superb electric fountain in Washington which would be worth traveling to see. A very suitable site for it would be the center of the flushing reservoir west of the Monument on the middle line of Seventeenth street. A number of these fountains have been erected in various cities already, and my reports for 1898 and 1899, as well as this one, give illustrations of the effects which can be obtained. There is one in Willow Grove Park, Philadelphia, another in Prospect Park, Brooklyn, and three have been erected this year at the Crystal Palace, London—all American throughout.

The electric power is used not only for illuminating effects, but also to pump the water through the fountain, thus making it independent of the head of water of the city system, and such a fountain located as suggested would obtain its water from the river, and thus be entirely independent of the city supply.

The cost of such a fountain, suitable for Washington, ranges from $25,000 to $40,000.

The boiler house of the Washington Monument could be utilized in establishing such a plant.

PARK CURBING.

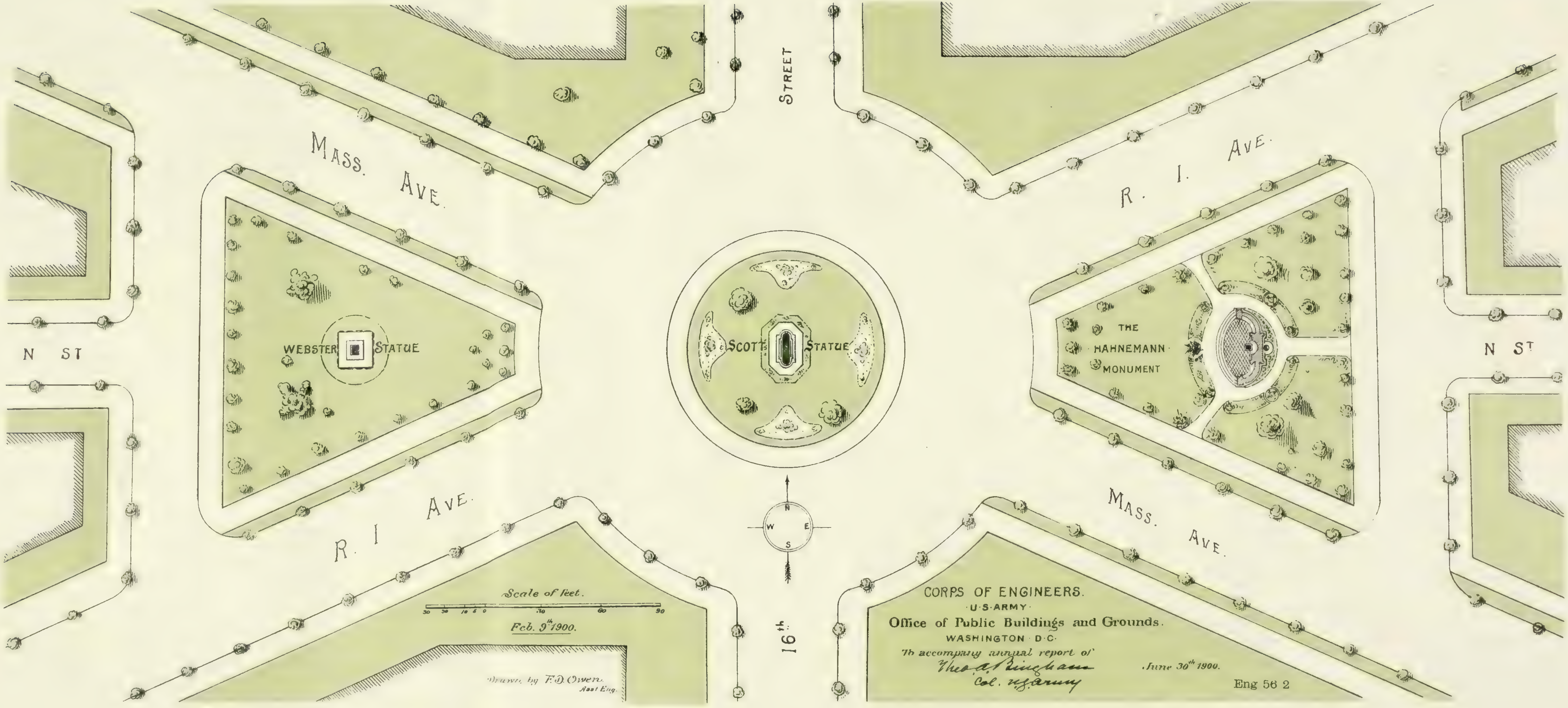
It being the wish of Congress that the public parks should be as open as possible, all the former high iron fences have been removed except where absolutely needed. This has left the edges of the parks with an unfinished appearance which, in many cases, is very unsightly.

It has been found by experience that a simple stone curbing gives a pleasing finish, and is sufficient to preserve a neat border line between park and sidewalk. Lafayette Square is an illustration.

Franklin Park, one of the prettiest and most frequented in Washington, suffers for lack of this. A simple but tasteful granite curb can be laid around it for $9,000 or less, and the appropriation of this amount is respectfully urged.

THE MAINTENANCE OF IMPROVED PARKS.

The improved parks and park spaces have been maintained in good condition during the year, the work consisting of mowing and raking lawns, cleaning gutters and drain traps, edging the grassed margins of roads and walks, caring for flower beds, trees, and shrubbery, gathering up and removing rubbish, pruning trees and shrubbery, and sweeping the paved walks through the parks and the pavements around them. Dead and unsightly trees and decaying shrubs have been removed, surfaces of gravel roads and walks repaired, raked, and rolled, board



16th STREET
MASS. AVE.
R. I. AVE.
N ST
WEBSTER STATUE
SCOTT STATUE
THE HAHNEMANN MONUMENT
R. I AVE.
MASS. AVE.
N St
N
E
S
W
Scale of feet.
30 20 10 5 0 30 60 90
Feb. 9th 1900.
Drawn by F.D. Owen. Asst Eng.
CORPS OF ENGINEERS.
U.S. ARMY.
Office of Public Buildings and Grounds.
WASHINGTON D.C.
To accompany annual report of
Theo. A. Bingham
Col. U.S. Army
June 30th 1900.
Eng 56 2

During the past year Reservation No. 126, at the intersection of Virginia and Georgia avenues and I street, and between Ninth and Eleventh streets SE., has been prepared as a playground.

MARKING RESERVATIONS.

During the year five reservations had their corners indicated by the planting of stones marked "P. B. & G." This has been found a useful precaution, particularly for unimproved reservations, often preventing innocent trespass by owners of adjoining property. The reservations marked were as follows:

Reservation 122, Virginia avenue and I street, between Fourth and Fifth streets SE.
Reservation 123, Virginia avenue and I street, between Sixth and Seventh streets SE.
Reservation 125, Virginia avenue and K street, between Eighth and Ninth streets SE.
Reservation 126, Virginia and Georgia avenues and L street, between Eighth and Ninth streets SE.
Reservation 229, North Carolina avenue, First and E streets SE.

Ninety of these marking stones have been cut and squared during the year and 76 lettered.

STATUES.

There are 19 statues in the national public grounds under charge of this office, as follows:

Daguerre.
General Hancock (equestrian).
General Scott (equestrian).
Admiral Du Pont (standing).
Professor Henry (standing).
General Thomas (equestrian).
Admiral Farragut (standing).
President Jackson (equestrian).
President Washington (equestrian).
President Garfield (standing).
General Lafayette (standing).
Mr. Webster (standing).
General Greene (equestrian).
President Lincoln (2) (standing).
Dr. Gross (standing).
General McPherson (equestrian).
Dr. Hahnemann (sitting).
General Rawlings (standing).

Those of Daniel Webster and Dr. Hahnemann were completed during the year. That of Webster was reported on last year. It was unveiled with appropriate ceremonies January 19, 1900.

In the case of the statue of Dr. Hahnemann, $4,000 was appropriated by joint resolution approved January 31, 1900 (Public, No. 3), for a foundation, which was built by this office between March 13 and April 7, 1900. The monument was built by the contractors between May 11 and June 21, 1900, on which date the unveiling ceremonies took place. Some finishing touches have still to be made.

Three statues are under construction, viz: General Sherman (equestrian), pedestal completed; General Logan (equestrian), pedestal completed; Albert Pike (standing), foundation completed.

Some of these statues have no inscription, as, for instance, Hancock, Lafayette, and others. It is thought it would be advisable to have simple inscriptions placed on all statues now unmarked, and a small estimate of $100 is made for this purpose.

The Lincoln statue in front of the city hall is in a precarious condition, and liable to be blown over in a high wind. The level of soil around it has been lowered since it was built. It should all be taken down, a solid foundation provided, and the shaft and statue reerected. An estimate of $600 is made for this work. If done, the site can be slightly changed to good advantage, and this is recommended.

During the year the stains on the bronze work of some of the statues in the parks and the worst stains on their stone pedestals were cleaned off and broken joints in the stonework of the pedestals repaired with cement where required.

PARK WATCHMEN.

By (legislative) act approved April 17, 1900, Congress provided for four much-needed additional night watchmen and for a sergeant. These additions go into effect July 1, 1900, and will add greatly to the efficiency of the force and the convenience of those who use the parks.

The entire force has also been uniformed, which is not only a factor of appearance and efficiency, but will enable the watchmen to be more easily found in case police assistance be required.

Two more day watchmen are urgently needed, the above said additional allowance having provided for only four of the six, the necessity for which was given at length in my annual report for 1899.

The one day watchman now allowed for the so-called "White Lot," or President's Park, is quite unable to cope with "scorching" bicyclers around the ellipse; with fast drivers, and trespassers on grass and shrubbery; with the crowds which assemble for band concerts and on other occasions there; and also patrol the 63 acres of this park.

The Monument grounds cover 78 acres, for which there is now no day watchman to see that the rules are enforced as to vehicles, bicycles, etc. There is also here a large space which is continually in use as a playground by boys and young men and which requires supervision. In the course of a year over 150,000 people pass through this park on the way to the Monument, and the Monument watchmen have their hands full at the Monument. Then in summer, owing to the crowds which frequent the bathing beach on the Monument grounds, there is further need of a day watchman.

I therefore respectfully urge upon the attention of Congress the necessity for 1 second day watchman, President's Park (grounds south of Executive Mansion), $720; 1 day watchman, Monument Park, $720.

It gives me pleasure to say that the present force of park watchmen perform their duties faithfully, and it is owing to their diligence that such good results have been attained with so limited a force. The imperative necessity for an increase in the force has been presented, and I respectfully urge an increase of pay of $5 per month for all day watchmen. In my judgment their services are as arduous as those of night watchmen. Their hours are as long; they must be more alert and attentive, owing to the greater passing of people and vehicles during the daylight hours; they have work to do in cleaning up their parks aside from watching, which night watchmen do not have; and, being more in evidence in the daylight, must take more trouble and be at some more expense to keep their clothes and appearance neat.

The entire extra cost for the 18 day watchmen per year asked for is only $1,080.

GROUNDS OF EXECUTIVE MANSION.

In addition to the usual work required for the care and maintenance of these grounds, the following has been accomplished: The iron fence on the north, east, and west sides of the grounds has been painted repairs made to the three large fountains, and parts of them painted. A lamp post with a boulevard lamp has been placed in position on each of the two stone pillars at the east end of the mansion.

Uniform of
·U·S·Park Watchmen·
Public Buildings and Grounds.
Washington·D·C·

Adopted
une. 30th 1900.

Color,
Park Green.

Eng 56 2

EASTER MONDAY EGG ROLLING 19[illegible]0.

Necessary attention was paid to the trees, vines, and shrubs. A severe windstorm on August 2, 1899, did considerable damage to branches of trees, and one fine yellow buckeye tree on north lawn was destroyed. A large bed planted with rhododendrons and azaleas, most of which were old and worthless, was denuded of the plants, the bed prepared and replanted with new plants purchased for that purpose and with such of the old plants as were worth saving. In November, 1899, the summer blooming and decorative plants were removed from the flower beds and 41 of them planted with about 53,000 early spring flowering bulbs, all but about 4,000 of which had been grown in the greenhouses of the mansion. In the spring the bulbs were removed and 45 beds planted with summer bedding plants.

In accordance with the usual custom the inclosed grounds south of the mansion were thrown open to the children on Easter Monday, April 16, 1900. In order to protect the flower beds, small trees and shrubs, and the large south fountain from injury, temporary wire fencing was placed around them. Consequently no damage was done to them. The grounds were, however, badly littered, and some damage was done to the lawn surfaces. The cost of erecting and removing temporary wire fencing, guarding the grounds, cleaning up litter, and resodding or seeding bare places on lawns where the grass was destroyed by the trampling of the crowd was about $114.

These grounds are insufficiently drained, and much damage is done to the gravel walks and brick gutters by washouts during each heavy rain storm. Additional drainage facilities should be provided, and an estimate for the work, amounting to $1,500, is submitted and earnestly recommended.

A list of the trees and shrubs in these grounds is appended, together with a map showing their locations.

List of trees and shrubs in the grounds of the Executive Mansion.

[Compiled by Mr. Henry Pfister, Head Gardener.]

[DESCRIPTION: T. for tree; S. for shrub; E. for evergreen tree; E. S. for evergreen shrub; and V. for vines. The numbers refer to locations on map.]

SECTION I.

No.	Description.	Name.	No.	Description.	Name.
1	T.	American elm.	20	T.	Acacia nemu. (Japan acacia).
1a	T.	American elm, planted March, 1878, by President R. B. Hayes.	21	T.	Quercus concordia (Golden-leaved oak).
2	T.	European linden.	22	T.	Sugar maple.
3	T.	American linden.	23	T.	American ash.
4a	T.	Sweet gum, planted Apr. 6, 1892, by President Benjamin Harrison.	24	S.	Magnolia halleana,
			25	S.	Peach (doubled red flowered).
5	T.	Koelreuteria japonica.	26	S.	Magnolia species.
6	T.	Salisburia adiantifolia, maiden-hair tree.	27	E. S.	Boxbush (or boxwood).
			28	E. S.	Bambus (clump of 10).
7	T.	Scarlet oak, planted Apr. 6, 1892, by Benjamin H. McKee, grandson of President Harrison.	29	S.	Desmodiums, lilacs, and Japan maples in a clump.
			30	S.	Japanese quinces, forsythias, and Hydrangeas paniculata in a clump.
8	T.	Magnolia macrophylla.			
9	T.	Acer. tartaricus ginnala.	31	S.	Lagerstræmias, forsythias, double mock oranges and althæas.
10	T.	Horse chestnut.			
11	S.	Halesia tetraptera (silver bell).	32	E.	Picea cephalonica.
12	T.	Red oak.	33	E.	Picea nordmanniana.
13	T.	European beech.	34	E.	Pinus excelsa.
14	T.	Silver-leaved poplar.	35	E.	Abies orientalis.
15	T.	Scarlet maple.	36	S.	Prunus pissardii.
16	T.	English ash.	37	E.	Abies orientalis compacta.
17	T.	Buckeye (yellow).	38	T.	Magnolia soulangeana.
18	T.	Swamp maple.	39	S.	Weigelia rosea.
19	T.	Tulip poplar.	40	E.	Abies amabilis.

List of trees and shrubs in the grounds of the Executive Mansion—Continued.

[DESCRIPTION: T. for tree; S. for shrub; E. for evergreen tree; E. S. for evergreen shrub; and V. for vines.]

SECTION II.

No.	Description.	Name.	No.	Description.	Name.
1	T.	American elm.	20	T.	Horse-chestnut.
2	T.	Acacia nemu (Japanese acacia).	21	T.	American ash.
3	T.	Mountain ash.	22	T.	English ash.
4	T.	Tulip poplar.	23	T.	Buckeye (yellow flowered).
5	T.	Swamp maple.	24	E. S.	Yuccas in a clump.
6	T.	Sugar maple.	25	T.	Cut-leaved beech.
7	T.	European oak.	26	T.	Fern-leaved beech.
8	T.	American black oak.	27	T.	Cut-leaved weeping birch.
9	T.	Rivers' (purple leaved) beach.	28	S.	Magnolia halleana.
10	T.	Scarlet maple.	29	E.	Abies (Picea) polita.
11	S.	Cytisus laburnum (golden chain).	30	E.	Abies amabilis.
12	E. S.	Bambus (golden).	31	E.	Abies douglasii.
13	E. S.	Azalea amæna and hypericum moserianum, in a clump.	32	S.	Paeonia (tree).
			33	E.	Abies nobilis.
14	T.	American linden.	34	E.	Abies canadensis compacta glauca.
15	T.	European linden.	35	S.	Japanese maples.
16	T.	Buckeye (red flowered).	36	V.	Lonicera halleana (Hall's honeysuckle.
17	T.	Silver-leaved poplar.			
18*	T.	Scarlet oak, planted March 18, 1898, by President McKinley.	37	E. S.	Boxwood (tree).
			38	S.	Deutzia giaulis pæonias, lilacs, and yuccas in a clump.
19	T.	Soft or silver maple.			

SECTION III.

No.	Description.	Name.	No.	Description.	Name.
1*	T.	American elm, planted March, 1880, by Scott Hayes, youngest son of President Hayes.	17	E.	Pinus excelsa.
			18	E.	Thuia occidentalis aurea.
			19	E.	Taxus baccata washingtoni.
1	T.	American elm.	20	E. S.	Aucuba variegata.
2	T.	Fern-leaved beech.	21	S.	Prinos verticilatus (black alder).
3	T.	Scarlet oak, planted April 6, 1892, by Marie L. McKee, grand daughter of President Benjamin Harrison.	22	E. T.	Magnolia grandiflora.
			23	E.	Thuia siberica in a clump.
			24	T.	Horse-chestnut (double flowered).
4	T.	American ash.	25	S.	Halesia hispida.
5	T.	Soft or silver maple.	26	S.	Smoke tree, hypericums, lilac, cornus, viburnum, and lonicera in a clump.
6	T.	Sugar maple.			
7	T.	American sycamore.			
8	T.	English ash.	27	S.	Japanese maples, althæas, and double-flowering almonds in a clump.
9	S.	Cytisus laburnum (golden chain).			
10	T.	Rivers's (purple-leaved) beech.	28	E. S.	Limonia trifoliata (hardy orange).
11	T.	European linden.	29	S.	Tree pæonia, herbaceous pæonias, althæas, deutzia gracilis, lagerstræmia, and lilacs in a clump.
12	T.	Horse-chestnut.			
13	T.	Tulip poplar.			
14	T.	Acer platanoides (sycamore maple).	30	V.	Clematis paniculata.
15	T.	Paulownia imperialis.	31	V.	Bignonia grandiflora, large-flowered trumpet vine.
16	S.	Dimorphanthus mandschuricus.			

SECTION IV.

No.	Description.	Name.	No.	Description.	Name.
1	E. S.	Boxwood.	16	S.	Japanese quince.
2	T.	Acer platanoides (sycamore maple).	17	S.	Spirea prunifolia.
3	V.	Wistaria japonica (white flowered).	18	S.	Spirea reevesii.
4	S.	Magnolia glauca.	19	S.	Forsythia fortunii.
5	E.	Taxus baccata pyramidalis.	20	S.	Spirea reevesii flora plena.
6	S.	Syringa Ligustrina.	21	V.	Rose (Empress of China).
7	S.	Peach (double white flowered).	22	V.	Wistaria sinensis.
8	S.	Cornus mas (Cornelian cherry).	23	V.	Honeysuckle (Hall's and red flowered).
9	S.	Peach (double red flowered).			
10	E.	Pinus strobus compactus nanus.	24	V.	Clematis and roses.
11	T.	Purple-leaved beech.	25	E.	Thuia siberica (Hedge).
12	T.	Horse-chestnut.	26	E. T.	Magnolia grandiflora (Callisonier var.).
13	S.	Mock orange.			
14	S.	Lilac (white flowered).	27	E. T.	Magnolia grandiflora (ordinary var.).
15	S.	Lilac (Persian).			

List of trees and shrubs in the grounds of the Executive Mansion—Continued.

[DESCRIPTION: T. for tree; S. for shrub; E. for evergreen tree; E. S. for evergreen shrub; and V. for vines.]

SECTION V.

No.	Description.	Name.	No.	Description.	Name.
1	T.	Paulownia imperialis.	39	E. S.	Box. Green foliage.
2	E.	Libocedrus decurens (red wood).	40	S.	Berberis purpurea (purple leaved).
3	E.	Abies douglasii.	41	S.	Spirea reevesii flora plena.
4	E.	Abies pungens (Colorado blue spruce).	42	S.	Hypericum moserianum.
5	E. T.	Magnolia grandiflora.	43	S.	Desmodium japonicum (white and purple variety).
6	E.	Picea nordmanniana.	44	T.	American sycamore.
7	T.	Soft or silver maple.	45	E.	Abies (Picea) polita.
8	T.	Spanish chestnut.	46	E.	Abies pinsapo.
9	T.	Cedrella sinensis.	47	E.	Cedrus deodara glauca.
10	T.	Cork-barked oak.	48	E.	Thuiopsis standishii.
11	T.	Pin oak.	49	E.	Cupressus lawsoniana.
12	T.	White oak.	50	E.	Yucca.
13	T.	Black oak.	51	S.	Magnolia Lenne.
14	T.	Japanese oak (Daimio).	52	T.	Crab apples (Siberian).
15	T.	Horse-chestnut.	53	S.	Ptelea trifoliata aurea.
16	T.	Black walnut.	54	S.	Lagerstraemia, rosea, alba, and purpurea.
17	T.	Acer negundo (ash-leaved maple).			
18	T.	Acer platanoides (sycamore maple).	55	S.	Weigelia rosea.
19	S.	Japanese red bud (Judas tree).	56	S.	Spirea reevesii.
20	S.	Cerasus jap. rosea pendula (weeping cherry).	57	S.	Cornus mas. (Cornelian cherry).
21	T.	Cut-leaved beech.	58	T.	Carpinus betulus (European hornbeam).
22	T.	American beech.	59	T.	American ash.
23	S.	American red-bud (Judas tree).	60	T.	English ash.
24	T.	Acer schwedlerii (red-leaved maple.)	61	S.	Diospyrus lotus (European persimmon).
25	S.	Cerasus acida (sour cherry).			
26	T.	Sugar maple.	62	E.	Pinus excelsa.
27	T.	Koelreuteria japonica.	63	T.	Tulip poplar.
28	S.	Chionanthus virginicus fringe tree).	64	E.	Picea cephalonica.
			65	T.	Buckeye (yellow flowered).
29	S.	Exochorda grandiflora.	66	T.	Larix europaea (European larch).
30	S.	Lilac (Persian).	67	S.	Snowball.
31	S.	Calycanthus floridus (sweet shrub).	68	S.	Magnolia halleana.
32	S.	Althæa rosea.	69	S.	Spirea prunifolia.
33	S.	Mock orange.	70	S.	Jasminium nudiflorum.
34	S.	Mock orange (double flowered).	71	S.	Japanese cherry.
35	S.	Ribes aurea (Missouri currant).	72	S.	Deutzia crenata.
36	S.	Almond (double pink flowered).	73	S.	Lilac (white flowered).
37	E. S.	Box. Yellow foliage.	74	S.	Lilac (common purple).
38	S.	Paeonia (tree),			

SECTION VI.

1[1]	T.	American elm, planted by John Quincy Adams.	22	S.	Cornus florida flora rubra (red-flowered dogwood).
2	T.	Horse-chestnut.	23	T.	Acacia nemu. (Japanese acacia.)
3	T.	Rivers's (purple leaved) beech.	24	S.	American red bud (Judas tree).
4	E. S.	Box tree (Buxus sempervirens).	25	T.	Tulip tree, with variegated foliage.
5	T.	Soft or silver maple.	26	S.	Hammamelis japonica (Japanese witch hazel).
6	T.	Sugar maple.			
7	S.	Magnolia purpurata.	27	T.	Willow (Russian).
8	T.	Platanus orientalis (Oriental sycamore).	28	T.	Norway maple.
			29	T.	Cherry (double yellow flowered).
9	S.	Peach (double white flowered).	30	T.	Koelreuteria paniculata.
10	T.	Horse-chestnut (double flowered).	31	T.	European beech.
11	S.	Styrax japonica,	32	T.	Crab apple (Siberian).
12	E.	Picea nobilis.	33	T.	Tulip poplar.
13	E.	Abies pungens (Colorado blue spruce).	34	T.	Purple beech (weeping).
			35	T.	Virgilia lueta (yellow wood).
14	E.	Pinus cembra compacta (Swiss mountain pine).	36	S.	Cerasus sieboldii, flora rosea plena (double pink-flowered cherry).
15	E.	Pinus coraeensis (Corean pine).	37	T.	Acer wierii (cut-leaved maple).
16	E.	Cerasus avium alba plena (double white cherry).	38	T.	Cut-leaved beech.
			39	T.	Cut-leaved birch (European).
17	E.	Picea pectinata species.	40	T.	Paulownia imperialis.
18	E.	Pinus excelsa (Himalayan pine).	41	T.	English ash.
19	E.	Cedrus atlantica glauca.	42	S.	Peach (double red flowered).
20	E.	Pinus austriaca (Austrian pine).	43	T.	Catalpa bignonoides.
21	E.	Pinus strobus (white pine).	44	T.	Acer negundo (ash-leaved maple).

List of trees and shrubs in the grounds of the Executive Mansion—Continued.

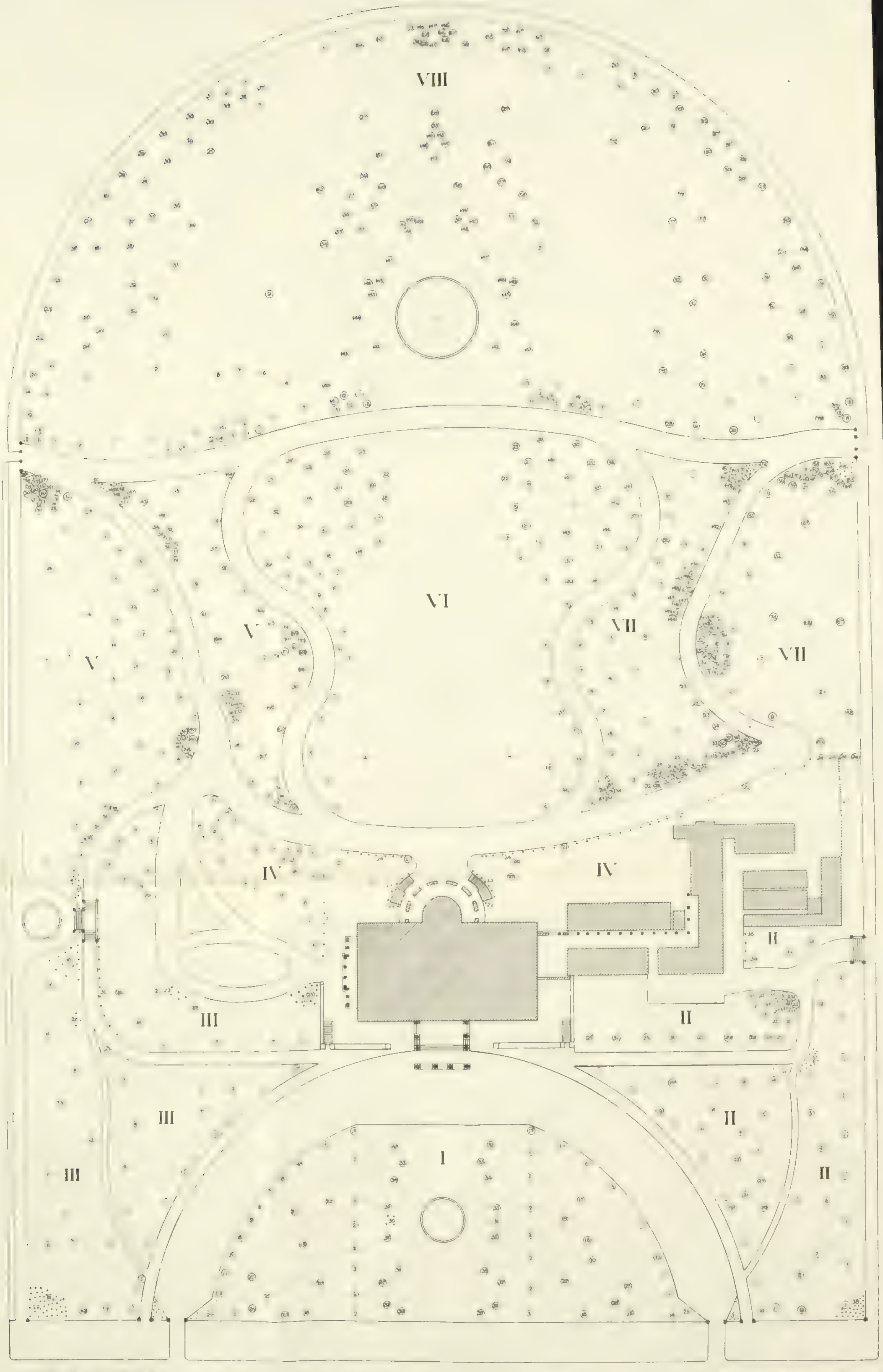
[DESCRIPTION: T. for tree; S. for shrub; E. for evergreen tree; E. S. for evergreen shrub; and V. for vines.]

SECTION VII.

No.	Description.	Name.	No.	Description.	Name.
1	T.	Soft or silver maple.	43	T.	Koelreuteria paniculata.
2	T.	Horse-chestnut.	44	S.	Exochorda grandiflora.
3	T.	Quercus concordia (golden-leaved oak).	45	S.	Almond (double rose flowered).
4	T.	Gleditschia sinensis (honey locust).	46	S.	Mock orange.
5	T.	Scarlet oak.	47	S.	Lagerstraemia rosea.
6	T.	Laurel-leaved oak.	48	S.	Jasminium nudiflorum.
7	T.	Rivers's purple beech.	49	S.	Spirea fortunii.
8	T.	American locust.	50	S.	Hydrangea Thomas Hogg.
9	T.	Weeping silver linden.	51	S.	Spirea reevesii flora plena.
10	T.	Acer ritenbachi (dark-leaved maple).	52	T.	Black oak.
11	T.	Carpinus betulus (European hornbeam).	53	T.	Ulmus camp. pendula camperdownii (Camperdown weeping elm).
12	E.	Pinus excelsa.	54	T.	American linden.
13	S.	Cornus florida (dogwood).	55	T.	Cut-leaved beech.
14	T.	Scarlet maple.	56	T.	Sugar maple.
15	T.	Phellodendron amurense (Chinese cork tree).	57	S.	Chionanthus virginica (fringe tree).
16	T.	Catalpa bignonoides	58	S.	Hydrangea paniculata.
17	S.	Syringa japonica (Jap. tree lilac).	59	S.	Deutzia crenata flora plena.
18	T.	Sweet gum (liquidambar styracfl).	60	S.	Amorpha fruticosa (false indigo).
19	T.	Crab apple (Siberian).	61	S.	Spirea prunifolia.
20	T.	English walnut.	62	S.	Forsythia fortunii.
21	T.	Spanish chestnut.	63	S.	Acer poly. jap. disectum purpureum.
22	T.	Tulip poplar.	64	S.	Acer poly. jap. atrapurpureum.
23	E. S.	Bambusa metake.	65	S.	Paeonia (tree).
24	E. S.	Boxwood.	66	E. S.	Yucca in a clump.
25	S.	Ligustrum ovalifolium (California privet).	67	T.	English elm.
26	S.	Halesia hispida.	68	T.	Silver-leaved poplar.
27	S.	Japanese quince.	69	T.	Paulownia imperialis.
28	E. S.	Mahonia japonica.	70	S.	Lilac (purple, large flowered).
29	S.	Hypericum prolificum.	71	S.	Duetzia gracilis.
30	S.	Mock orange (double flowered).	72	E. S.	Yucca filamentosa.
31	S.	Spirea thunbergii.	73	T.	Black walnut.
32	S.	Paeonia herbaceous.	74	T.	American sycamore,
33	E.	Cedrus atlantica.	75	S.	Lilac (Persian).
34	E.	Abies orientalis.	76	S.	Althaea variegata.
35	E.	Abies (Picea) polita.	77	S.	Ceanotus (gloir de plantier).
36	S.	Weigelia rosea folis variegatis.	78	S.	Lagerstraemia alba.
37	E.	Picea nordmanniana.	79	S.	Calycanthus floridus (sweet shrub).
38	E.	Abies pungens (Colorado blue spruce).	80	S.	Weigelia rosea.
39	S.	Lagerstraemia violacea.	81	S.	Althaea rosea.
40	S.	Rosa rugosa.	82	S.	Limonia trifoliata (hardy orange).
41	T.	Betula alba (European birch).	83	E. S.	Boxwood (tree).
42	T.	Acacia nemu (Jap. acacia).	84	S.	Spirea, reevesii.
			85	E.	Thuia occidentalis pyramidalis.
			86	T.	Acer ginnala.

SECTION VIII.

No.	Description.	Name.	No.	Description.	Name.
1	T.	American elm.	23	T.	American ash.
2	T.	Salisburia adiantifolio (maidenhair tree).	24	T.	Field maple.
3	T.	Willow-leaved oak.	25	T.	Sophora japonica (Japanese varnish tree).
4	T.	Laurel-leaved oak.	26	T.	Scarlet maple.
5	T.	Acer schwedlerii.	27	T.	Paulownia imperialis.
6	E.	Thuia siberica.	28	T.	Acer negundo (ash-leaved maple).
7	E.	Abies excelsa.	29	T.	English ash.
8	E.	Picea nordmanniana.	30	T.	Horse chestnut.
9	T.	Ulmus campestris pendula camperdownii (Camperdown weeping elm).	31	T.	Virgilia lutea (yellow wood).
10	E.	Thuia occidentalis.	32	T.	Swamp cedar.
11	S.	Mock orange.	33	E.	Thuia occidentalis filifera.
12	S.	Lilac (common purple).	34	T.	Olive oak.
13	E. S.	Boxwood.	35	T.	Cork-barked oak.
14	S.	Althæa rosea.	36	T.	Black oak.
15	T.	Wild cherry.	37	E.	Abies canadensis (hemlock).
16	T.	Plantaus orientalis (Oriental sycamore).	38	E.	Pinus scoticus (Scotch pine).
17	T.	Silver-leaved linden.	39	S.	Andromeda arborea (sorrel tree).
18	S.	Rhus cotinus (smoke tree).	40	T.	Scarlet oak.
19	T.	Sugar maple.	41	E.	Virginian cypress.
20	T.	Koelreuteria paniculata.	42	T.	Fagus sylvaticus pendula (weeping beech).
21	S.	Cytisus laburnum (golden chain).	43	S.	Tamarix africana.
22		Norway maple.	44	T.	Pyrus malus parkmanni (large-flowered apple tree).
			45	S.	Weigelia rosea.



CORPS OF ENGINEERS
U.S. ARMY
Office of Public Buildings and Grounds
WASHINGTON D.C.

GUIDE TO TREES AND SHRUBS IN THE
GROUNDS OF THE EXECUTIVE MANSION

To accompany the annual report of
Theo. A. Bingham
June 30th 1900 Col. U.S. Army

Drawn by [illegible] Lane
Henry Pfister Head Gardener

List of trees and shrubs in the grounds of the Executive Mansion—Continued.

[DESCRIPTION: T. for tree; S. for shrub; E. for evergreen tree; E. S. for evergreen shrub; and V. for vines.]

SECTION VIII—Continued.

No.	Description.	Name.	No.	Description.	Name.
46	S.	Forsythia fortunii.	68	S.	Amygdalus floro-rubro pleno (dwarf-flowering almond).
47	S.	Lilac (white-flowered).			
48	S.	Snowball.	69	S.	Japanese quince.
49	S.	Spirea reevesii flora plena.	70	S.	Hydrangea paniculata.
50	S.	Spirea fortunii.	71	T.	Acer ritenbachi.
51	E.	Abies orientalis.	72	E.	Pinus excelsa.
52	E.	Abies amabilis.	73	T.	European linden.
53	E.	Taxus pyramidalis.	74	S.	Ptelea trifoliata.
54	E. S.	Ilex aquifolia (European holly).	75	E.	Abies pectinata.
55	S.	Virburnum plicatum.	76	E.	Thuia orientalis.
56	E. S.	Ilex opaca (American holly).	77	T.	White oak.
57	T.	Magnolia saulangeana.	78	T.	Large-leaved white oak.
58	E.	Thuia siberica.	79	S.	Cornus florida pendula.
59	S.	Magnolia purpurea.	80	T.	Quercus macrophylla.
60	S.	Magnolia lenne.	81	T.	Betula alba (European birch).
61	E. S.	Magnolia grandiflora.	82	T.	Walnut-leaved ash.
62	E. S.	Boxwood (tree).	83	T.	Willow-leaved ash.
63	E.	Taxus baccata washingtonii.	84	T.	Cut-leaved ash.
64	E.	Taxus baccata.	85	T.	European ash.
65	S.	Lonicera fragrantissima.	86	T.	Buckeye (small-leaved variety).
66	S.	Lonicera tartarica alba.	87	S.	Acer polymorphum purpureum.
67	E.	Thuia vervæneana.			

PROPAGATING GARDENS, INCLUDING THE GREENHOUSES AND NURSERY.

Necessary repairs were made to the various greenhouses during the year, and the large and valuable collection of plants was maintained in good condition.

Repairs were made to decayed woodwork in the houses, such as staging, rafters, sashes, wall plates, posts, rafters, floor joists, etc., and all of the new work painted. The brick walls of some of the greenhouses were repaired and in some cases reconstructed. New tin gutters were made and put up on the houses and old gutters and down spouts repaired. Broken glass was replaced with new and old glass reputtied where needed. The exteriors of 7 greenhouses were repainted and much miscellaneous painting done. Necessary attention was paid to the boilers and heating pipes.

There were propagated during the year 764,794 park bedding plants in 62 kinds and 170 varieties, and about 15,000 miscellaneous plants in about 100 varieties, making a total of nearly 780,000 plants. There were also propagated and grown for the grounds of the Treasury Department building 13,919 plants.

There were purchased during the year, under contract, 74,500 flowering bulbs for winter forcing in the greenhouses and for fall planting and early spring bloom in the parks. There were also purchased 2,096 plants.

The following plants were grown in the greenhouses for fall, winter, and spring bloom:

4,385 smilax.
2,157 carnations.
54 asparagus.
2,279 roses in six varieties.
2,775 chrysanthemums for stock and fall bloom.

There were potted and boxed for winter forcing the following bulbs:

2,314 freesia.
1,200 lilium.
10,800 Roman hyacinths.
3,000 Dutch hyacinths.
3,000 narcissus.
7,000 tulips.
5,000 pips lily of the valley.
2,708 carnation plants.
1,132 violet plants for stock and winter forcing.

In the autumn 9,550 chrysanthemum plants were sent out to the parks to be planted for early fall bloom and 5,460 pansy plants and 89,375 early spring flowering bulbs for early spring bloom. In April, May, and June 640,712 bedding plants and 1,265 tropical and subtropical plants were sent out for summer planting in the parks; 27 vases were stocked with plants, 1,408 plants being used for the purpose, and water lilies were planted in the basins of some of the fountains; 12,020 surplus bedding plants were furnished for the grounds of public institutions, and the few plants remaining given to whoever applied for them.

In the nursery the lawns were mown, young stock cared for, and the grounds maintained in a cleanly condition. A trench 447 feet long and 1 by 2 feet was opened to carry off surface water during heavy rains; 22½ feet of new flagstone walk was laid and 98 feet of cobblestone gutters constructed, old walks and gutters repaired, and 322 feet of terra-cotta drainpipe laid. Gravel roads and walks were resurfaced with new gravel. A road was opened on the east side of the nursery grounds on line of Fifteenth street, between C and D streets SW. The surface graded over in making the road was 350 feet long and 70 feet wide. A piece of ground in the southeast part of the grounds 280 feet long and 80 feet wide was also graded. The water pipe in the grounds was extended by laying 89 feet of additional pipe.

There were planted in these grounds—

764 pansy plants for stock and early spring bloom.
4,124 carnations.
755 dianthus.
375 pyrethrum.
220 geraniums.
1,300 gladiolus bulbs.
5,412 miscellaneous plants, all for stock and summer flowering.
1,684 miscellaneous plants for stock.

There were purchased during the year 380 young trees and 1,307 young shrubs. There were sent out for planting in the parks 82 young trees and 1,153 young flowering shrubs and 37,875 early spring flowering bulbs for fall planting.

In the sundry civil appropriations act approved June 6, 1900, Congress provided an appropriation for the construction of an iron and brick storehouse in these grounds, making the funds immediately available. A project for the work was submitted to the Chief of Engineers, United States Army, June 8, 1900, and approved by the Secretary of War June 16, 1900. Work was at once commenced moving some old wooden buildings from the site selected for the new structure, and the excavation for its walls begun.

Extension improvements can well be made at these gardens. Over 700,000 plants are annually propagated at the greenhouses for use in the summer and autumn decorations of the public parks. The beautiful water lilies and other aquatic plants used in many of the fountain basins are also propagated here.

The various structures are rapidly becoming unserviceable for the purposes for which they are urgently needed, having been erected by our own workmen out of second-hand material and at very cheap cost. We have only a small annual appropriation of $2,000. Congress having now provided the storehouse so much needed, the necessity is urgent for—

A second story on the potting house	$1,500
One palm house	2,500
One subtropical plant house	2,500

Only second in importance to the above items is the necessity for something to replace the tumble-down shops at the gardens. An extraordinary amount of repairing and manufacture of the thousand and one articles used in the park work is done by our own men. But they can not work without proper tools and equipment, and it would be economy to put all the shops together in one building, both by making all our tools more available and by providing better shelter for them. A plain brick building costing $8,500 would answer every purpose and economize space and labor.

The additional and much-needed space which was temporarily added to the nursery from the Potomac Flats by transfer made in May, 1899, by Col. Charles J. Allen, Corps of Engineers, by authority of the Chief of Engineers, has been inclosed with a post and wire fence along the west and south boundary lines, and an embankment of earth constructed along that line with materials dumped without expense to the United States. Considerable filling of the low grounds in this addition has also been done with materials obtained in the same manner, over 12,200 loads of filling having been deposited during the year.

This office is frequently in receipt of requests for the loan of plants from the gardens for the use of churches, fairs, festivals, etc., and demands are constantly made for flowering and decorative plants for private purposes.

All such requests have to be declined, as either the loan or gift of any plants would be in violation of the following extract from the act of Congress approved June 20, 1878:

> *Provided*, that hereafter only such trees, shrubs, and plants shall be propagated at the greenhouses and nursery as are suitable for planting in the public reservations, to which purposes only the said productions of the greenhouses and nursery shall be applied.

After the annual spring planting in the parks is completed it sometimes happens that there is a small surplus of bedding plants on hand. These are divided among such public reservations or institutions as the State, War, and Navy building, Marine Barracks, Washington Aqueduct grounds, Fort Myer Military Reservation, and various hospitals and orphan asylums. After these are supplied, should there still be a few such surplus plants remaining, they are given to whoever may ask for them.

This office now furnishes, after its park planting is completed, many plants and shrubs for beautifying the grounds of the various Executive Departments, the labor in planting and care being furnished by each Department.

The $1,000 now provided by Congress enables the office to plant and beautify the grounds of the various Executive Departments throughout the city.

RESERVATIONS NORTH OF PENNSYLVANIA AVENUE AND WEST OF THE CAPITOL.

This division of the city embraces all the public reservations located between First and Twenty-eighth streets west and B street and Florida avenue north, the majority of which are in an advanced condition of improvement and require the constant attention of a force of skilled laborers for their proper maintenance.

It includes the highly improved parks, known as Washington Circle, Rawlins Square, Du Pont Circle, Scott Circle, Lafayette Square, Franklin Square, Farragut Square, McPherson Square, Mount Vernon

Square, Iowa Circle, Thomas Circle, Judiciary Square, and a number of other smaller highly improved reservations.

In addition to the work required for the care and maintenance of the improved parks and park places in this division, the following has been accomplished:

Du Pont Circle.—Repairs were made to the asphalt walks, the area resurfaced amounting to 234 square yards.

Farragut Park.—Nineteen square yards of asphalt walk were repaired and resurfaced. A new gravel walk, 54 feet long and 6 feet 10 inches wide, was constructed on west side of the park, midway between I and K streets, as an entrance into the park from the sidewalk on Seventeenth street.

Franklin Park.—The strip of gravel on each side of the asphalt walks was paved with asphalt, making the asphalt pavement the full width of the walks, the area covered amounting to 448 square yards. Nineteen square yards of old asphalt walks were repaired. The watchman's lodge has been painted.

Judiciary Park.—The paving of the E street roadway was completed during July, 1899; that portion of it which was left unfinished at the close of the fiscal year 1899 for want of funds, viz, from the center of the park out to Fifth street, having been covered with an asphalt roadway pavement 370 feet long and 23½ feet wide, covering an area of 981 square yards. Additional asphalt footwalk, covering an area of 358 square yards, was constructed, and 262 square yards of old asphalt footwalk were repaired and resurfaced. The iron post and chain fence on the Fourth street side of the park from Indiana avenue north to F street, and the fences on the east and west sides of the court-house building and around the parkings fronting that building were removed for use in inclosing some of the smaller recently improved reservations. Nine gas-lamp posts and lamps along the Fifth street boundary, which were no longer needed, were taken down and removed to the nursery. Nineteen shrubs were planted, some cast-iron drainpipe was laid, and a new draintrap constructed. Five iron posts were placed at the end of the central walk leading to the Pension Office building, to prevent the passage of vehicles over the walk. The watchman's lodge was repaired and painted.

Lafayette Park.—Worn places in the asphalt walks were repaired, the area resurfaced, amounting to 19 square yards. The fence inclosing the statue of General Jackson and the interior of the watchman's lodge were painted. The District Government has replaced the old brick pavement of the sidewalk around this park with a new cement pavement. In doing this work a change was made in the grades which necessitated the taking up and resetting of the granite coping on the boundary line of the park, the work being done without expense to the United States by the contractor who laid the pavement. This coping having been lowered on the south side and raised on the north, east, and west sides, will necessitate some grading of the park surfaces, and this will be done as soon after July 1, 1900, as possible. The granite curbing inclosing the mound around Lafayette statue was also lowered by the contractor, the necessary grading of the mound being done by employees of this office.

McPherson Square.—Thirteen square yards of asphalt walk were repaired and resurfaced.

Mount Vernon Park.—This park having been selected as the site for

BRONZE VASE, LAFAYETTE SQUARE 1900.

TOOL HOUSE PRESIDENT'S PARK, PERIOD OF THE FIFTIES.

a building for the Washington Public Library by the act of Congress approved March 3, 1899 (Vol. 30, Stat., p. 1372) such of the public property and materials in the park as were worth saving have been removed therefrom by this office. The iron post and chain fence has been taken down and removed, the large iron fountain removed and erected in another reservation, two drinking fountains and the park settees removed, and all shrubbery of any value taken up for use in other parks. The sod and soil were also removed from the ground within the limits of the site of the new building, the sod used on other portions of the public grounds, and the soil, about 812 cubic yards, hauled to the storage yard of this office. The watch box was removed, four lamp-posts and lamps taken down, and the iron gratings removed from catch-basins. The District Government caused the line of the public sewer through this park on the line of Eighth street to be changed, brought around the site of the building, and connected with the sewer on K street. In June 1900, the work of excavating for the library building was commenced.

President's Park (south of Treasury Department, Executive Mansion grounds, and State, War, and Navy Departments.)—Repairs have been made to the gravel roads and walks, 407 cart loads of fresh gravel being used for the purpose.

The width of the stone gutter way on the north side of the roadway southeast, south, and southwest of the Executive Mansion grounds has been increased from 2½ feet to 4 feet for a length of 1,230 linear feet in order to more rapidly carry off the large volume of water during heavy rain storms and prevent the sides of the gravel roadway from being washed out. The curbing, gutter, and draintrap over the large trunk sewer in the northeast side of the park, which had settled below the grade, were raised and broken portions of gutters through the park repaired. Repairs were made to broken joints in the stonework of the two lodges. A bridle path, about 1 mile in length and 17 feet wide, was laid off around the park a short distance from the boundary line, staked out, and covered with sand, for the use of equestrians only. Wooden bridges were placed across gutters where required to connect the path with roadways. The top sections, each 9 feet long, were removed from the electric-light poles around the borders of the ellipse, to shorten the poles and bring the lights nearer the ground. The lower branches were cut, about 7 feet from the ground, from the elm trees on each side of the roadways and roadway entrances, and the District Government reset the uneven flag pavements on the west and south sides of the park and repaired the uneven tar roadway pavement on the east side of the park on the line of Fifteenth street.

Washington circle.—An asphalt pavement covering an area of 219 square yards has been laid on the gravel walk running north and south through the circle. The interior and exterior of the watchman's lodge has been painted.

Reservation 32, Pennsylvania avenue, Fourteenth and E streets N W.—The surface of the reservation was spaded, sown with grass seed, border of sod laid around the boundary and on each side of the walks, and six ornamental evergreens and two flowering trees planted.

Reservation 61, Massachusetts and Rhode Island avenues and N street between Sixteenth and Seventeenth streets N W.—The mound around the statue of Daniel Webster in this reservation was graded, covered with soil, and sown with grass seed.

Reservation 72, Massachusetts avenue and I street between Fifth and Sixth streets NW.—Two large magnolia trees removed from Mount Vernon Park have been planted in this reservation.

Reservation 77, Massachusetts and New Jersey avenues, First and G streets NW.—This partially improved circle has been highly improved during the year. A large iron fountain, removed from Mount Vernon square, was erected in the reservation, and water supply and drain pipes for its service introduced. Gravel walks were constructed through the circle and around the fountain. The ground on the west side of the circle was lowered about 6 inches over a space 6 feet in width back from the line of post and chain fence, to bring it to the grade of the adjoining pavement, and the space resodded. Four groups of shrubbery were planted around the fountain, and American elm trees were planted 30 feet apart around the circle, 8 feet back from the fence line. In these plantings 96 flowering shrubs and 16 trees were used. The iron posts of the inclosing fence were straightened, the chain tightened, and the fence and the fountain painted.

Reservations 98 and 134, Virginia and New Hampshire avenues, Twenty-fifth and G streets NW.—These reservations, hitherto unimproved, have been highly improved during the year. They have been made into one reservation. They have been graded, the surface of the ground covered with soil and compost, and seeded, and water pipe introduced for irrigation. The reservation has been inclosed with an iron post and chain fence. A granite block apron on the pavement line on the south side of the reservation, opposite Twenty-fifth street, was taken up, 43 linear feet of 6-inch curb set and 43 feet of brick pavement 6 feet wide laid in place of the apron, thus connecting and completing the brick sidewalk on that side of the reservation. Eighty-five flowering shrubs and 20 trees have been planted.

Reservation 99, Virginia avenue, Twenty-fourth and G streets NW.—This unimproved reservation has also been improved. It has been graded, surfaced with soil and compost, bordered with sod, seeded, water pipe introduced, a post and chain fence erected and painted, and 144 flowering shrubs planted.

Reservation 100, Virginia avenue, Twenty-fourth and F streets NW.—This unimproved reservation has been graded, surfaced with soil and compost, bordered with sod and seeded, water pipe introduced, 62 flowering shrubs and two trees planted, and a post and chain fence erected and painted.

Reservation 102, Virginia avenue and E street, between Twenty-first and Twenty-second streets NW.—This reservation has also been improved during the year. Its surface has been covered with soil and compost, and seeded, sod laid around the borders, water pipe introduced, 58 flowering shrubs and 5 trees planted, and the reservation inclosed with an iron post and chain fence.

Reservation 156, Rhode Island avenue, Tenth and Q streets NW.—The iron post and chain fence inclosing this reservation has been painted.

Reservation 157, Rhode Island avenue, Ninth and Q streets NW.—The iron post and chain fence has been painted.

Reservation 158, Rhode Island avenue, Seventh and R streets NW.—The iron post and chain fence has been painted.

Reservation 163, Vermont avenue, Thirteenth and O streets NW.—A fountain with concrete basin and brick and cement coping has been constructed, and water and drain pipe introduced for its service,

Reservation 173, New York avenue and I street, between Eleventh and Twelfth streets NW.—A group of 13 flowering shrubs has been planted at the east end of the reservation.

Reservation 174, New York avenue and I street, between Tenth and Eleventh streets NW.—Three large magnolia trees which were removed from Mount Vernon square and three other trees and two shrubs were planted in this reservation.

Reservation 187, Louisiana avenue, Sixth and D streets NW.—This unimproved reservation has been graded, surface soiled and sodded, water pipe introduced, 44 flowering shrubs and 12 trees planted, and an iron post and chain fence erected and painted.

Reservation 188, Indiana avenue, Third and D streets NW.—The post and chain fence on the east (Third street) side of this reservation was moved in 2 feet in order that the public sidewalk might be widened by the District government, which also laid a new cement sidewalk on the Indiana avenue side of the reservation.

Reservation 195, New Jersey avenue and First street, between Massachusetts avenue and H street NW.—This unimproved reservation was improved during the year. Some old trees were removed, the ground graded, seeded, and bordered with sod, water pipe introduced, 56 flowering shrubs planted, signs prohibiting trespassing and iron guards to prevent it placed in position; a watchman's box which had been removed from Mount Vernon square has been placed in this reservation and painted.

Sheridan circle, Massachusetts avenue, Twenty-third and R streets NW., and Truxtun circle, Florida avenue, North Capitol and Q streets.—These circles having been set aside as public parks by the Commissioners of the District of Columbia; they were transferred to the control of the Chief of Engineers by letter of March 15 from the Commissioners and accepted by letter from the Chief of Engineers dated April 7, 1900, the transfer having been made under the authority contained in the act of Congress of July 1, 1898, volume 30, Statutes, page 570. Sheridan circle has been numbered 57/a on the records of this office and Truxtun circle 277/a. In April, 16 European linden trees were planted around Sheridan circle, and in June the District government lifted the brick pavement around that circle and raised the curb to conform to a change made in the grade of the surrounding streets.

RESERVATIONS IN SOUTHWEST DIVISION.

This division of the public grounds embraces the area lying between First and Seventeenth streets west and B street north, and includes the large and important parks known as Henry and Seaton parks, the Smithsonian grounds, and Monument grounds.

The usual annual work required for maintaining the improved reservations in good condition was performed.

The following special work was also accomplished:

Henry Park.—Repairs were made to the gravel road leading to the bridge across Sixth street. The floor of that bridge was repaired by employees of the Baltimore and Potomac Railroad Company. The strip of gravel on both sides of the asphalt path on the walk from the entrance at B street SW. was removed, replaced with soil, and sown with grass seed, making the walk the width of the asphalt. Thirty-eight panels of the high iron fence on the north side of the grounds

from Seventh street east to the Baltimore and Potomac Railroad station were cleaned and painted.

Monument grounds.—A new entrance, 30 feet wide, to the roadway in the southeast part of the grounds from Fourteenth street was constructed so as to be immediately opposite the entrance to the roadway into the grounds of the Agricultural Department. The old entrance to this roadway, which was located farther south, was then closed by filling it up with earth, setting curb, laying sidewalk, pavement, and sowing that portion of it within the grounds with grass seed.

A bridle path, about 5,200 feet in length and 18 feet wide, for equestrians only, was laid off and staked out around these grounds, a short distance within the boundary line. The flagstone sidewalk along the line of B street NW., from Fifteenth to Seventeenth streets, was taken up and relaid by employees of the District government. Permission was granted May 14 to a committee of the local order of the "Nobles of the Mystic Shrine" to use that portion of the Monument grounds between the roadway north of the Monument and B street north for the purpose of a display of fireworks on the evening of May 23. Tents, poles, and stake and wire fencing were erected by the committee for the purpose of the display, which were taken down and removed after the display was over. No damage was done to the grounds by this use of them.

Seaton Park.—An asphalt pavement, 661 feet long and with an average width of 5½ feet, was laid over the entire length of the gravel walk running from road at Four-and-a-half street out to Missouri avenue, between Four-and-a-half and Sixth streets. This pavement covers an area of 417 square yards. Repairs were made to the gravel roads, over 300 cart loads of gravel being used for the purpose.

Smithsonian grounds.—The asphalt roadway from Seventh to Twelfth streets was repaired, the area resurfaced amounting to 312 square yards. Repairs were made to gravel roads. The watchman's lodge near the entrance at Tenth street NW. was set upon brick piers and repaired. Thirty-three lamp-posts, 2 drinking fountains, and 50 iron posts on park line south of National Museum and across the road south of Smithsonian building were painted.

Reservation 111, Virginia avenue and B street, between Eleventh and Twelfth streets SW.—

Reservation 113, Maryland and Virginia avenues and C street and Seventh and Ninth streets SW.—

The iron post-and-chain fences inclosing these two reservations have been painted.

Reservation 293, Canal, First, and N streets SW.—This reservation has long been occupied in violation of law by a party who built a frame house thereon in 1888. The case was placed in the hands of the United States district attorney for the District of Columbia in 1892. On March 19, 1897, the supreme court of the District of Columbia rendered an opinion that the said party was a trespasser and unlawfully occupying the reservation, and ordered and decreed that he remove all buildings, fences, and other obstructions from the grounds within thirty days and deliver the said premises to the possession of the superintendent of public buildings and grounds. From this decree the trespasser appealed, but his appeal was dismissed on October 5, 1897, and he was ordered to perform the decree of March 19, 1897, on or before the 1st day of December, 1897. This he has not done, and on the 13th of

September, 1898, the United States marshal entered upon the premises, dispossessed the occupant of the house, and turned the property and the keys of the building over to this office.

Nothing further was done in the matter until by letter of April 21, 1900, the District Commissioners informed this office that the building had, in their opinion, become a public nuisance and requested me to assist them by abating it. The question was, whether I could do this without becoming personally liable for damages. The facts were reported to the Department under date of May 17, 1900, and by indorsement of June 8, 1900, I was given authority to remove the building. The house will be removed after July 1, 1900, when a new appropriation becomes available.

RESERVATIONS EAST AND SOUTH OF THE CAPITOL.

This division of the city includes within its limits the highly improved reservations known as Lincoln, Garfield, Folger, Stanton, and Marion parks.

In addition to the general work required for the care of the improved parks and park places in this division the following special work was accomplished:

Folger Park.—The iron post-and-chain fence and 6 lamp-posts have been painted.

Garfield Park.—Repairs were made to the gravel roads. Two catch-basins were constructed in east section of the park and 66 feet of drain-pipe laid. A watch box was placed in the park, brick piers built under it, and the box repaired and repainted. A board walk about 80 feet long and 3 feet wide was laid, connecting Virginia avenue and the south road in the western section of the park, and a wire fence about 60 feet long was erected in eastern section to prevent trespassing. The work, commenced in June, 1899, by workmen employed by the District government for repairing and restoring that portion of the grounds torn up during the construction of a large public sewer through the park, was completed in July, 1899.

Lincoln Park.—An asphalt pavement 5 feet wide and covering an area of 478 square yards was laid on the gravel walk leading in from East Capitol street on the east side of the park and 8 square yards of old asphalt walk were repaired and resurfaced. Posts in the inclosing fence which were out of line were straightened, dead and dying trees removed, two drinking fountains repainted, and the cement bottoms of the two large fountains repaired.

Marion Park.—Eight lamp-posts have been repainted.

Stanton Park.—An asphalt pavement 5 feet in width and covering an area of 215 square yards has been constructed on the gravel walk leading in from C street, on the west side of the park. The post-and-chain fence was repaired and painted and the lamp-posts also given a coat of paint.

Sherman Park.—The iron-post-and chain fence has been painted.

Reservation 19, between K and L and Fifth and Seventh streets SE.—This unimproved reservation, portions of the surface of which were much below grade, has been graded and surface soiled, about 4,631 cubic yards of earth and 356 cubic yards of soil having been used in the work. Of this material some 2,733 cubic yards of earth and 156 cubic yards of soil were hauled into the reservation without expense

to the United States. A large quantity of gravel and broken stone has been temporarily stored on the reservation for use in constructing park roads and walks. Two wooden fence barricades have been erected on the reservation across the line of Sixth street to prevent the passage of vehicles.

Reservations 37, 38, 39, 40, 41, 42, 43, and 45, Pennsylvania avenue, between Third and Eighth streets SE.—The iron post-and-chain and post-and-bar fences inclosing these reservations have been painted.

Reservation 47, Pennsylvania and South Carolina avenues, Eighth and C streets SE.—This small unimproved reservation has been graded, sodded, and water pipe introduced.

Reservation 122, Virginia avenue and I street, between Fourth and Fifth streets SE.—This unimproved reservation has been graded, top-dressed with manure and soil, bordered with sod, and water pipe introduced. Granite marking stones were set in the ground at the four corners of the reservation.

Reservation 123, Virginia avenue and I street, between Sixth and Seventh streets SE.—Has been graded, surfaced with soil and seeded, water pipe introduced, bordered with sod, a flagstone walk laid at east end as a passageway from Virginia avenue to I street, and granite marking stones set in the ground at the three corners of the reservation.

Reservation 125, Virginia avenue and K street, between Eighth and Ninth streets SE.—Has been graded, surface sodded, seeded, bordered with sod, water introduced, marking stones set in the ground at each of the four corners, and the reservation inclosed with an iron post and chain fence.

Reservation 126, Virginia and Georgia avenues and L street, between Ninth and Eleventh streets SE.—This large unimproved reservation has been improved during the year. It is designed for use as a playground. The ground has been graded, water pipe introduced and two hydrants erected, one at the east end and one at the west end, and necessary water-supply and drainage connections made. Tenth street, which formerly crossed the reservation, was closed, its area incorporated into the reservation, and iron posts erected on either side to prevent the passage of vehicles. Granite marking stones were set in the ground at the four corners of the reservation, and signs prohibiting the trespassing of vehicles erected at suitable points. Granite blocks for marking the limits of the proposed playgrounds were placed. A pair of goal posts and crossbars for football have been erected in the east end and five stones to mark positions for a baseball field placed in position, the cost of material and labor having been defrayed by a private citizen.

Reservations 203, 204, and 205, Maryland avenue, between First and Third streets NE.—The post-and-chain fences inclosing these reservations have been painted.

Reservation 206, Maryland avenue and D street, between Sixth and Seventh streets NE.—Has been graded and surfaced with soil.

Reservation 208, Maryland avenue, Ninth and E streets NE.—Graded, surfaced with soil, grass seed sown, a border of sod laid, and water pipe introduced.

Reservation 210, Maryland avenue and F street, between Eleventh and Twelfth streets NE.—Graded, surfaced with soil, seeded, bordered with sod, and water pipe introduced.

Reservation 211, Maryland avenue, F and Thirteenth streets NE.—Has been graded, sodded, and water pipe introduced.

Reservation 212, Maryland avenue and G street between Thirteenth and Fourteenth streets NE.—Graded, surface soiled, seeded, bordered with sod, and water pipe introduced.

Reservation 213, Maryland avenue, Fourteenth and G streets NE.—Graded, surfaced with soil, sodded, and water pipe introduced.

Reservation 225, Delaware avenue, First and F streets NE.—The post-and-chain fence inclosing the reservation has been painted.

Reservation 229, North Carolina avenue, First and E streets SE.—Granite marking stones were set in the ground at the four corners of the reservation.

SETTEES, TOOLS, MANURE, CONSTRUCTION AND REPAIR OF POST-AND-CHAIN FENCES, AND REMOVING SNOW AND ICE.

During the year, 185 park settees were repaired and 269 painted. All settees in the parks were examined, and those found loose were refastened to the ground with stakes and wire.

Repairs were made to lawn mowers, wheelbarrows, and miscellaneous tools, edged tools sharpened and kept in good order, and new tools purchased from time to time as required.

About 500 cubic yards of stable manure, 150 cubic yards of cow manure, and 296 cubic yards of potting sod were purchased, the greater part of the stable manure mixed with soil and made into compost and spread over park lawns and around young trees and shrubbery, part of the stable manure used in enriching flower beds, and the cow manure and the potting sod made into potting compost for plants. There were hauled from the grounds adjoining the Department of Justice building 199 cart loads of topsoil and deposited in the storage and compost grounds south of B street between Eighteenth and Nineteenth streets NW., and 531 cart loads and 302 wagon loads of soil were excavated in Mount Vernon square from the ground selected as a site for the building for the Washington Public Library and also deposited in those grounds, for use in making compost and topsoiling park surfaces. A fence of cedar posts and wire was constructed along the south and west boundary lines of the storage grounds. The length of the fence is 625 feet.

Repairs were made to iron fences, new caps placed on the iron posts of post-and-chain fences to replace broken and missing caps, posts out of line straightened, and repairs made to the iron chains where required. Six reservations were inclosed with iron posts and chain fences during the year.

The snow and ice were removed as soon as possible after storms from the walks through and sidewalks around the various parks and park places. The snow fall of last winter was very heavy, so that by the middle of February all but about $125 of the $1,200 allotted for "removing snow and ice" was expended, and on February 17, 1900, it was recommended that Congress be asked to provide an additional appropriation of $2,000. On March 19, 1900, Congress passed a resolution providing $1,000, but it was then too late to be of much service and only $40.88 was expended, the balance, $959.12, being returned to the Treasury.

PAINTING WATCHMEN'S LODGES, IRON FENCES, VASES, LAMPS, AND LAMP-POSTS.

Seven of the watchmen's lodges, 38 sections of the high iron fence on the north side of Henry Park, the iron railing around the statue of Gen-

eral Jackson in Lafayette Square, the iron post-and-chain fences inclosing Stanton Park and 26 of the small reservations, consisting of 1,638 posts and chains and 351 posts and bars; some of the flower vases, 66 lamp-posts, and the iron fence on east, west, and south sides of the Executive Mansion grounds have been painted.

HEATING WATCHMEN'S LODGES.

Gas radiators for heating purposes were purchased and placed in the park lodges of the following parks in November, one in each, excepting the lodge in Lafayette Park, in which two were placed, to replace the coal stoves formerly used:

Washington Circle.
Lafayette Park.
Judiciary Park.
Smithsonian grounds, one in each of the two lodges.
Stanton Park.
Dupont Circle.
Franklin Park.
Seaton Park.
Lincoln Park.
Iowa Circle.
Mount Vernon Square.

Thirteen in all.

WATER PIPES AND FOUNTAINS.

Repairs have been made to water pipes and valves from time to time, where necessary, new valves put on and new iron extension boxes placed over valves to replace old boxes. In the autumn the water was shut off from the various parks, the hose valves removed, stored in the shops at the nursery and repaired and repacked during the winter. In the spring the valves were replaced in the parks. During the year water pipe was introduced into nineteen reservations hitherto unprovided with irrigating facilities and additional water pipe was laid in the nursery grounds. The total quantity of water pipe laid during the year for irrigating purposes was 645 feet of 1-inch pipe, 249 feet of 1¼-inch pipe, 50 feet of 2-inch pipe, 28 feet of 3-inch pipe, 60 feet of 4-inch pipe, with the necessary valves. The iron extension boxes over the valves on that portion of the Capitol spring pipe line located in the low ground north of V street were raised to the established grade and brick manholes with iron covers built around them. These valves are three in number and are located, one at V street, near First street NW., and two on Albany street near First street. Marks showing the location of the pipe through this low ground were also raised to prevent them from being covered with earth deposited for filling and grading the grounds.

There are 21 small fountains with basins in charge of this office. Repairs were made to the cement basins of these fountains wherever needed, and they were cleaned out, stone copings repointed, stains removed from them, and the supply and waste pipes and valves maintained in order. The jets, which with a few exceptions are of very simple character, were removed from the fountains in the autumn, the water turned off, jets requiring it repaired, and all replaced in the spring. One fountain was constructed during the year, in reservation 163, at Vermont avenue, Thirteenth and O streets NW., and necessary water supply and drainage connections made, and the iron fountain in the center of Mount Vernon Square, on the site selected for the new building for the Washington Public Library, was taken down and reerected in the circle (reservation 77) at the intersection of New Jersey avenue, First and G streets NW.

There are 24 drinking fountains in the various parks, and these have been maintained in good order and repairs made when necessary. At the approach of winter the water was shut off and the dippers removed. In the spring the dippers were replaced and the water turned on. Two of the fountains were repainted during the year. The two fountains in Mount Vernon Square, on the site of the Washington Public Library, were taken down during the year and removed to the storage yard at the nursery.

LIGHTING THE PUBLIC GROUNDS.

The following parks are lighted with arc electric lights: Executive Mansion grounds, 10 lights; President's Park, 9 lights; Monument Park, 12 lights; Lafayette Park, 6 lights; Franklin Park, 9 lights; Judiciary Park, 9 lights, and Lincoln Park, 8 lights—a total of 63 lights.

The number of gas lamps not connected with meters lighted nightly during the year was 246 from July to September, 242 from October to April, and 238 in May and June. Each of these lamps burned about 3,000 hours and consumed about 15,000 cubic feet of gas. Two double-burner lamps and lamp-posts and 4 single-burner lamps and lamp-posts standing on the site of the Washington Public Library in Mount Vernon Square were taken down during the year.

In addition to the gas lamps mentioned in the foregoing paragraph, there are 71 burners in the Executive Mansion grounds connected with the meters in the Mansion. Two old lamp-posts and lamps in these grounds were taken down during the year, one at the east side and one at the west side of the Mansion, and 2 new lamp-posts with boulevard lamps were erected on the two low stone piers in front of the east portico.

All of the gas lamps in the public grounds have been maintained in good condition, minor repairs made, and old lanterns replaced with new boulevard lamps as the old ones became unserviceable.

It is earnestly hoped that the system of lighting the public grounds by electricity will be extended to the Smithsonian grounds and to the various improved parks throughout the city.

CONSTRUCTION AND REPAIR OF ASPHALT PAVEMENTS.

The following tabulated statement shows the area of asphalt roadway and foot-walk pavement constructed and repaired during the year:

Locality.	New roadway.			Repairs to roadways.	New walks.			Repairs to walks.
	Length.	Breadth.	Area.		Length.	Breadth.	Area.	
	Feet.	*Feet.*	*Sq. yds.*	*Sq. yds.*	*Feet.*	*Feet.*	*Sq. yds.*	*Sq. yds.*
Washington Circle					373	5	219	
Dupont Circle								234
Farragut Park								19
McPherson Park								13
Lafayette Park								19
Franklin Park					1,985	2	448	19
Judiciary Park	370	23½	981		611	5	358	262
Smithsonian grounds				312				
Seaton Park					661	5½	417	
Stanton Park					328	5	215	
Lincoln Park					837	5	478	8
Total	370		981	312	4,795		2,135	574

DEPARTMENTAL TELEGRAPH LINE.

The telegraph lines now under control of this office are as follows:

The line of overhead wires consists of 82 poles, covering a distance of about $3\frac{1}{2}$ miles, with a length of about 16 miles of wire. This line, starting from the State, War, and Navy building, runs to the Executive Mansion, thence to the Treasury Department, thence to G street, thence to Eighth street, thence to H street, thence to North Capitol street, and thence to the Capitol. Connected with it is one running from the Treasury Department along Fourteenth street to the Bureau of Engraving and Printing and Agricultural Department, and one down Fifth street to the Pension building. There are about 500 feet of 13-conductor Patterson cable running from the cable pole in the Capitol grounds into the basement of the Senate, and 250 feet of 20-conductor cable running from the cable pole on the corner of Seventeenth and G streets into the State, War, and Navy building.

During the year the main and local batteries received necessary attention, and were maintained in good working order. All crosses and other obstructions on the wires of the line were removed as soon as possible, instruments maintained in good condition, and some much-needed repairs made at different points on the line wires.

The Post-Office Department having moved from its old building to the new building of the city post-office, the telegraph office of the Department was moved under the supervision of the lineman of this office, the extra labor and necessary materials being furnished by the Treasury Department. All of the old wires running between the Interior Department and the old building of the post-office were removed from the roofs of both buildings and the old fixtures taken down.

The fixtures on the roofs of the Interior Department, Department of Agriculture, and Treasury Department were carefully gone over, securely fastened in place, the wires hauled up, and slack cut out. The fixture on roof of Government Printing Office was renewed and securely guyed. Owing to frequent trouble with the wires in the Department of Agriculture, which were run in an old flue in that building, the lines were rerun by a different route and the necessary connections made with the instruments in the telegraph office.

At the request of the Public Printer two wires were run on the departmental poles along North Capitol street from the Government Printing Office to E street NW., and all necessary wires run for a telephone connection with the Sixth precinct station of the Metropolitan police. The materials and labor expended in this work, except the service of the electrician of this office, were paid for by the Public Printer.

At the House of Representatives, the operator's table and instruments in the lobby were moved to another location and all connections made, the cost of the work, other than the services of the electrician of this office, being paid by the House. New local wires were run for the office in the Senate.

As stated in my last annual report, the wires of the line were broken down by a blizzard in February, 1899, which only accentuates the necessity for replacing the poles with a system of underground cables; and this is so apparent that argument in its favor is unnecessary.

Estimates have been carefully prepared and submitted in previous years. The cost of the underground system will be $25,000, and the matter is presented for such action as Congress may deem best.

OLD RECORDS OF THE CITY OF WASHINGTON.

On January 27, 1898, the United States Senate passed a resolution directing the Secretary of War to transmit to the Senate at as early a date as possible the numbers and locations of all lots in the District of Columbia the title to which the records in the office of the Commissioner of Public Buildings and Grounds show to be in the United States; also report of all lots in the District of Columbia sold or donated by the United States, the numbers of the squares in which such lots are located, the date of sale, the names of purchasers, and the amounts received.

A copy of the resolution was referred to this office on January 28 from the office of the Chief of Engineers, with request for early report, and on May 21, 1898, there was sent to the Chief of Engineers, in partial compliance with the requirements of the resolution, the following:

(1) List of lots in the city of Washington, D. C., the title to which the records of this office show to be in the United States, there being no record of the sale of said lots; and

(2) List of lots in the city of Washington, D. C., which are shown by the records of this office to have been donated by the United States.

On December 22, 1898, there was sent to the Chief of Engineers in further compliance with the resolution a partial "list of all lots in the District of Columbia sold by the United States, compiled from old records in the Office of Public Buildings and Grounds," and covering squares numbered from 1 to 245, consecutively, and on December 7, 1899, an additional list of lots sold was sent to the Chief of Engineers covering the squares numbered from 247 to 760, both inclusive. Since December, 1899, the work of compiling the list of lots sold has been continued. It was completed in June, 1900, and a list covering the squares numbered from 761 to 1149, both inclusive, will be sent to the Chief of Engineers in December, 1900, for transmittal to Congress.

The act of Congress approved March 3, 1899, provided:

SEC. 2. That the Secretary of War be, and he is hereby, authorized and directed to correct the records of the War Department in respect of any of the lots mentioned in Senate Document Numbered Two hundred and seventy-seven, Fifty-fifth Congress, second session (being a letter from the Secretary of War transmitting, in compliance with the resolution of the Senate of January twenty-seventh, eighteen hundred and ninety-eight, a letter from the Chief of Engineers, together with list of lots in the city of Washington, District of Columbia, the title to which the records of his office show to be in the United States, and list of lots in the city of Washington, District of Columbia, which are shown by the records of his office to have been donated by the United States), upon the filing by an actual occupant of any of the lots mentioned in said document sufficient proof that the said occupant or the party under whom he claims has been in actual possession of the said lot or lots for an uninterrupted period of twenty years, so that said records shall show the title to said lots to be in the said occupant.

Between the date of that act and June 30, 1900, the required proof has been furnished by the occupant, and the records corrected in the case of only eleven of the lots so far as this office is informed, the title to which was shown by the record to be in the United States.

On March 6, 1900, a report was submitted by this office on Senate bill 2725, Fifty-sixth Congress, first session. This report deals with the legal status of the Office of Public Buildings and Grounds, and recites what old records are in the keeping of this office. This paper and others bearing on the same subject were printed for the infor-

mation of Congress. As these papers are of importance and interest in connection with the work of this office, they are forwarded herewith as Appendix A.

EXTENSIONS OF BUILDINGS BEYOND THE BUILDING LINES IN THE CITY OF WASHINGTON.

The act of Congress approved March 3, 1891 (vol. 26, Stat. L., p. 868), provides that no permits shall hereafter be granted for the extension of buildings beyond the building line except with the concurrent approval of the Secretary of War.

This office, by direction of the Secretary of War, is charged with investigation and report on these cases. During the fiscal year ending June 30, 1900, 443 applications have been referred from the War Department to and reported upon by this office.

RESERVATIONS, WHICH ARE THE PROPERTY OF THE UNITED STATES, OCCUPIED, IT IS BELIEVED, IN VIOLATION OF LAW.

[See map in Annual Report for 1894.]

The following reservations, claimed as the property of the United States, are now occupied, it is believed, without authority of law:

Reservations Nos. 113, 127, and 197, by the Baltimore and Potomac Railroad Company.

Reservation No. 226, by the Baltimore and Ohio Railroad Company. This reservation has been occupied since 1884 by a large derrick and used as a yard. No record of proper authority therefor can be found. The matter has time and again been reported in the annual reports of my predecessor, and has also been reported to the law officers of the Government. The members of the Northeast Washington Citizens' Association have lately made a renewed effort to have this reservation restored to the United States and improved for the beautifying of that part of the city.

Reservation No. 125, by the Central Union Mission, as a place of worship.

Reservation No. 186, by the Bethany Chapel of the New York Avenue Presbyterian congregation.

Reservation No. 249 is occupied as a lumber yard by a party who claims to rent it from a gentleman in Port Deposit, Md.

Reservations Nos. 137, 138, 141, 152, 164, and 169 have been inclosed with iron or wire fences and partially improved by the owners of adjacent property.

The following also are improved and utilized by adjacent property owners: Nos. 65, 67, 139, 143, 161, 162, 167, 168, 175, 208, and 284.

STATUE OF GENERAL SHERMAN.

The site is in the northeast corner of the President's Park, south of the Treasury. The terrace, buttresses, and steps belonging to the pedestal were completed in December, 1899, since which date the pedestal has been ready to receive the bronze work. In December a wooden fence 10 feet high was erected around the completed pedestal. This office has been enabled to procure a large amount of the earth filling required to raise the grade of the ground around the pedestal

without expense to the United States, and since October, 1899, about 7,781 cubic yards of earth has been deposited and spread by different persons at their own expense, and 95 cubic yards from excavations made by this office.

As stated in my last annual report, the sculptor, who is also the contractor with the Government for the entire work, was put to considerable unexpected expense in connection with the foundation for the pedestal, being obliged, owing to the marshy character of the ground, to construct a subfoundation not provided for in the original contract. In order to reimburse him for this extra and unforeseen expense, Congress, in the deficiency appropriation act, approved June 6, 1900, appropriated the sum of $9,555.05, which amount was paid him by this office on June 23, 1900.

STATUE OF GENERAL LOGAN.

The pedestal was completed in April, 1898. In July, 1899, a cement concrete column was constructed in the interior of the bronze pedestal as an additional support for its top plate or cover.

At the request of the contractor, who is also the sculptor, the time for the completion and placing of the equestrian statue, which had previously been extended for one year from December 4, 1898, to December 4, 1899, has been again extended by proper authority for one year to December 4, 1900, with a proviso that no further extension will be allowed and that the statue must be in position and complete in all respects by that date.

STATUE OF GEN. ALBERT PIKE.

On January 21, 1899, reservation 188, at the intersection of Indiana avenue, Third, and D streets NW., was, under the authority contained in the joint resolution (Public No. 17) of Congress, approved April 9, 1898, designated as the site for a statue of Gen. Albert Pike, to be presented to the people of the United States by the Masonic fraternity. During the month of July the sculptor of the statue caused the concrete foundation for the pedestal to be constructed, and in June, 1900, the delivery of stone for the pedestal and preparation for its erection had been commenced.

MONUMENT TO SAMUEL HAHNEMANN.

The joint resolution of Congress, approved January 31, 1900, granted permission to the Hahnemann monument committee of the American Institute of Homeopathy to erect a monument in honor of Samuel Hahnemann in such place in the city of Washington, D. C., other than the Capitol or Library grounds, as should be designated by the Chief of Engineers, United States Army, the chairman of the Joint Committee on the Library, and the chairman of the monument committee, and appropriated the sum of $4,000 for the building of a foundation upon which to place the monument.

By letter of February 19, 1900, from the office of the Chief of Engineers, this office was informed that reservation 64, east of the Scott statue and at the intersection of Massachusetts and Rhode Island avenues and N street, between Fifteenth and Sixteenth streets NW., had

been selected as the site for the monument, and was directed to assume charge of the construction of the foundation and the erection of the monument.

On March 13, 1900, excavation for the foundation was commenced and completed March 21, when the concrete foundation was commenced and completed April 7. On May 11 the contractor employed by the monument committee of the Society of American Homeopathists commenced the erection of the monument, which was practically completed June 21, 1900, on which date it was unveiled with impressive ceremonies.

Of the $4,000 appropriated for the foundation only $1,240 has been expended, leaving an unexpended balance of $2,760, which can be well expended in improving the ground around the monument, and it is suggested that the balance be made available by Congress for that purpose.

MONUMENT AND WHARF AT WAKEFIELD, VA., THE BIRTHPLACE OF WASHINGTON.

No work has been done during the year beyond the usual care extended by the United States watchman in charge.

As heretofore reported, the wharf was damaged by high tide and wind on Tuesday, October 18, 1898. The timbers were carried off from two spans, Nos. 8 and 9, counting from the inner side of the pierhead. Span No. 7 was left suspended on one broken pile and in danger of being carried away by the next high wind or tide. It was reported that the timbers which were carried away were scattered along the shore for 3 miles in each direction. The timbers are those from under which the iron screw piles, 12 in number, were broken by ice in February, 1897, of which reports, with estimate of cost of repairs, amounting to $987, were submitted by this office to the Chief of Engineers February 20 and 25, 1897. There are no funds available for repairing the wharf, and nothing can be done until an appropriation is provided for the purpose by Congress.

In June, 1899, a gentleman residing at Wakefield was granted a revocable license by the War Department to repair the wharf with a temporary flooring on spruce-pine piles at his own expense and without cost to the United States, and under that permit, in July and August, he constructed a 10-foot bridgeway on 8 pine piles connecting the two broken ends of the wharf.

UNITED STATES WHARF PROPERTY, WASHINGTON, D. C.

By the act of Congress approved March 3, 1899, entitled "An act relative to the control of wharf property and certain public spaces in the District of Columbia," the following described property is placed under the immediate jurisdiction and control of the Chief of Engineers of the United States Army: "The banks of the Potomac River from the north line of the Arsenal grounds to the southern curb line of N street south;" * * *

By letter of March 11, 1899, from the office of the Chief of Engineers, I was directed, as representative of the Chief of Engineers, to assume control of the said wharf line and to prepare and submit to his office, under the provisions of section 2 of the act, such rules and regulations as I may deem necessary for the government and proper care of the property mentioned.

On May 12 a report was submitted by this office to the Chief of Engineers upon that portion of this wharf property which is under its control and which lies between "the north line of the Arsenal grounds and the southern curb line of N street south."

On the night of July 16, 1899, a heavy windstorm blew down a part of one of the old warehouses on the O street portion of this wharf property. As the part left standing was liable to fall at any time and cause some accident, a small gang of men was set at work on July 20 tearing down the remainder of the old buildings, and when completed the old materials were used in building a fence along the shore line to prevent persons from walking out on the old wharf or into the river. The fence is 218 feet long and 6 feet high. The old material of any value not used in its construction was hauled to the propagating gardens. The entire work was completed on July 29, and in September a signboard was placed on the fence, stating that it is United States Government property and prohibiting trespassing.

This wharf property is in a very unsightly and dirty condition, covered with tumbled-down buildings, old useless piles, and pieces of wharf, house boats, squatters, etc. It should be at once cleared off and cleaned up, old piles and useless and rotten buildings and cabins torn down, and be put in a condition for future improvements.

An estimate of $5,000 is submitted for this purpose.

SUMMARY OF WORK DONE DURING THE YEAR.

For convenience of reference a brief summary of the more important items of work accomplished during the year is given, as follows:

Executive Mansion.—The electric light and power cables placed in the concrete tunnel constructed last year and their carrying capacity increased. An additional line of 10-inch cast-iron pipe, 195 feet in length, placed in the tunnel to drain north area way and the large fountain basin at north front. A new lead-covered cable, 530 feet in length, for the automatic telephone service between Executive Mansion and State, War and Navy Departments building, run in the conduit between those buildings. New sashes with plate glass put in windows of three rooms. The blue parlor redecorated and refurnished. Walls of library repapered, ceiling frescoed, and furniture reupholstered and recovered. Two bedchambers repapered, and one bedchamber and two bathrooms repainted. New plumbing fixtures placed in one bathroom. Corridor on second floor repainted and repapered and a new carpet laid. Woodwork in thirteen rooms in basement repainted. A silver-polishing apparatus with electric motor placed in engine room. Cabinet room repainted and one office room repapered. Much miscellaneous painting done. New carpets laid in three rooms and new straw matting in two rooms. New window draperies placed in five rooms, new lace curtains in one room, and new loose covers on furniture in four rooms. The interior and exterior of the conservatory repainted. Extensive repairs and improvements made in the stable of the mansion.

Washington Monument.—New tap wires run from main wire to the electric lamps from bottom floor to 380-foot landing. New telephones placed in elevator car, engine room, boiler house, and lodge house.

Public grounds.—A roadway 350 feet long and 70 feet wide opened on east side of nursery grounds, on line of Fifteenth street, and a piece of ground 280 feet long and 80 feet wide in southeast part of the grounds

graded. The ground added to the area of the nursery on the west side during the previous fiscal year inclosed with a post-and-wire fence, and an earth embankment built along west boundary line; 12,200 loads of materials for filling low portions of those grounds received without expense to the United States.

In the propagating gardens 780,000 bedding plants propagated for planting out in the public parks. Twenty-one unimproved parklets, containing 8.5 acres, brought to their first stage of improvement, one of them having been prepared as a playground, six inclosed with iron post-and-chain fences, and a fountain constructed in one. A new walk constructed on west side of Farragut Park as an entrance into center of park from Seventeenth street. A bridle path about a mile long, for equestrians only, constructed around President's Park, and one about same length constructed in the Monument grounds. A new entrance from Fourteenth street to roadway in southeast part of Monument grounds constructed opposite entrance into grounds of Agricultural Department, and old entrance closed. Asphalt pavements in the parks extended by 981 square yards of roadway and 2,135 square yards of footwalk; 312 square yards of asphalt roadway and 574 square yards of asphalt footwalk repaired and resurfaced. Ninety-eight feet of cobblestone gutter constructed, and 322 feet of drainpipe laid. Marking stones placed at the corners of five of the unimproved parklets. Eighty young trees and 1,153 young flowering shrubs planted. A fence 625 feet long, of cedar posts and wire, constructed along the south and west boundary lines of the compost and storage grounds. Thirty-eight sections of high iron fence, the fence on east, west, and south sides of Executive Mansion grounds, 1,638 posts and chains, 351 posts and bars in fences around reservations, 66 lamp-posts and lamps, some of the flower vases, and 7 watchmen's lodges painted. Gas radiators placed in 12 watchmen's lodges to replace coal stoves formerly used. One thousand and thirty-two feet of additional water pipe laid. Brick manholes with iron covers built around the three shut-off valves on Capitol spring pipe line north of V street, and marks in low ground showing location of pipe raised to grade. The iron fountain in Mount Vernon square taken down and reerected in reservation 77. Four hundred and forty-three applications for permits beyond the building line investigated and reported upon. The terrace, buttresses, and steps belonging to the pedestal of the statue of General Sherman completed. The foundation for the pedestal of the statue of General Albert Pike constructed by the sculptor. The foundation for the monument to Samuel Hahnemann constructed by this office, and the monument erected by the monument committee of the Society of American Homeopathists. A fence erected in front of the O street portion of the United States wharf property lying between the Arsenal grounds and N street south. An addition built to the stable of public buildings and grounds.

THE PRESSING NEEDS OF THIS DEPARTMENT.

1. The work of this department has now reached a point where the need of a suitable palm house is imperative. Congress provided the means last year for a storehouse, which was absolutely essential, but in the work of the office it is necessary to keep on hand a considerable supply of palms of various kinds, which are used not only for

outdoor decorations during the summer, but during the winter season, when they would ordinarily be housed, they are utilized very successfully in the decoration of the Executive Mansion on official occasions. As the improvement of the parks in Washington progresses the number of plants and flowers which are propagated for their ornamentation increases rapidly, requiring an ever-increasing amount of greenhouse room for their growth and preparation. On this account the space required for the propagation of the outdoor plants and flowers has practically crowded out any available space for palms. Moreover, the dimensions of a greenhouse suitable for the propagation of park plants do not give the shape necessary for a palm house, and as all of the greenhouses at the propagating gardens have been built of secondhand material by our own workmen, it has been impossible so far to construct a proper house for palms; therefore the estimate of $2,500 submitted for this purpose is regarded as essential and indispensable to the proper progress of our work.

2. Only second in necessity to the palm house is the need of a suitable building to contain the shops of this department. Extraordinary amount of repair and manufacture of the thousand and one articles used in the park work is done by our own men, and we have gradually accumulated a very fair assortment of tools, but the buildings in which they are housed and the work is done are the cheapest kinds of sheds made of secondhand material, and now in almost an untenantable condition. It is also impossible to keep them dry from rain or even to lock them securely against intrusion. A mere inspection of these sheds is sufficient to show the necessity and the economy of combining all the shopwork at the propagating gardens into one building. Request is therefore urgently made for a plain brick building to be used for the purpose above indicated and to cost not more than $8,500.

3. While it can not be claimed that it is in any way necessary to improve all of the parks still remaining unimproved within three years, still it is respectfully urged that, taking the number of unimproved parks as 145 and allowing $1,000 apiece on an average, it would be much more economical, instead of spending $10,000 per year for fourteen and a half years, to spend $50,000 a year for three years. Not only would the average cost of improvement for each park be thereby reduced, but enough could be saved in the course of the work to supply the necessary subdepots and subnurseries, which are becoming necessary in other parts of the city.

In this connection reference is respectfully made to the data given in this report regarding the cost of improvement and maintenance of parks in Washington.

Estimates for the fiscal year ending June 30, 1902.

Salaries of employees, public buildings and grounds, etc.:	
1 assistant engineer in office public buildings and grounds	$1,800.00
1 office clerk	1,800.00
1 office clerk	1,600.00
1 messenger	840.00
1 landscape gardener	2,000.00
1 surveyor and draftsman	1,500.00
Overseers, draftsmen, copyists, foremen, gardeners, mechanics, and laborers	35,000.00
1 sergeant of park watchmen	900.00
1 day watchman in Lafayette Park	720.00
1 day watchman in Franklin Park	720.00
2 day watchmen in Smithsonian grounds, at $720 each	1,440.00
2 night watchmen in Smithsonian grounds, at $720 each	1,440.00

Salaries of employees, public buildings and grounds—Continued.

1 day watchman in Judiciary Park	$720.00	
1 night watchman in Judiciary Park	720.00	
1 day watchman at Lincoln Park and adjacent reservations	720.00	
1 day watchman at Iowa Circle	720.00	
1 day watchman at Thomas Circle and neighboring reservations	720.00	
1 day watchman at Washington Circle and neighboring reservations	720.00	
1 day watchman at Dupont Circle and neighboring reservations	720.00	
1 day watchman at McPherson and Farragut parks	720.00	
1 day watchman at Stanton Park and neighboring reservations	720.00	
2 day watchmen at Henry (Armory) and Seaton parks, at $720 each	1,440.00	
2 night watchmen at Henry (Armory) and Seaton parks, at $720 each	1,440.00	
1 day watchman at Mount Vernon Park and adjacent reservations	720.00	
2 day watchmen at grounds south of Exécutive Mansion, at $720 each	1,440.00	
1 night watchman at grounds south of Executive Mansion	720.00	
1 watchman for greenhouses and nursery	720.00	
1 day watchman at Monument Park	720.00	
1 night watchman at Monument Park	720.00	
1 day watchman at Garfield Park	720.00	
2 night watchmen at Garfield Park, at $720 each	1,440.00	
1 watchman for the care of the monument and dock at Wakefield, Va., the birthplace of Washington	300.00	
		$66,620.00
Contingent expenses, public buildings and grounds		600.00
Improvement and care of public grounds:		
Improvement and maintenance of grounds south of Executive Mansion	$4,000.00	
Ordinary care of greenhouses and nursery	2,000.00	
For the construction of a brick building for shops for carpenter, plumber, blacksmith, painter, etc., for the entire system of parks under office of public buildings and grounds	8,500.00	
For construction of a palm house at propagating gardens	2,500.00	
Ordinary care of Lafayette Park	1,000.00	
Ordinary care of Franklin Park	1,000.00	
Improvement and ordinary care of Lincoln Park	2,000.00	
Care and improvement of Monument grounds	5,000.00	
Continuing improvement of reservation No. 17 and site of old canal northwest of same	3,000.00	
Construction and repair of post-and-chain fences, repair of high iron fences; constructing stone coping about reservations, painting watchmen's lodges, iron fences, vases, lamps, and lamp-posts; manure and hauling the same and removing snow and ice; purchase and repair of seats and tools; trees, tree and plant stakes, labels, lime whitewashing, and stock for nursery; flowerpots, twine, baskets, wire, splints, moss, and lycopodium, to be purchased by contract or otherwise, as the Secretary of War may determine; care, construction, and repair of fountains; abating nuisances, cleaning statues, and repairing pedestals	16,050.00	
For improvement, care, and maintenance of various reservations	20,000.00	
For improvement, care, and maintenance of Smithsonian Grounds	2,500.00	
For improvement, care, and maintenance of Judiciary Park	2,500.00	
For laying asphalt walks in various reservations	2,000.00	
For improvement, care, and maintenance of grounds of Executive departments	1,000.00	

Improvement and care of public grounds—Continued.		
For improvement and maintenance of Executive Mansion grounds (within iron fence)	$1,000.00	
For necessary drainage of Executive Mansion grounds (within iron fence)	1,500.00	
For taking down, repairing, and resetting Lincoln statue in front of court-house	600.00	
For placing inscriptions on the unmarked statues of Lafayette and Hancock	100.00	
For 10 ornamental cast-iron fountains in various reservations throughout the city	10,000.00	
For granite coping for Franklin Park, 1,800 feet	9,000.00	
For preliminary improvement, care, and maintenance of 50 of the 145 unimproved reservations throughout the city at an average cost of $1,000 each	50,000.00	
		145,250.00
Care, repairs, fuel, etc., Executive Mansion:		
For care, repair, and refurnishing Executive Mansion, to be expended by contract or otherwise, as the President may determine	20,000.00	
Fuel for Executive Mansion, greenhouses, and stable	3,000.00	
Care and necessary repair of greenhouses	5,000.00	
Repairs to conservatory	2,000.00	
		30,000.00
Lighting the Executive Mansion and public grounds:		
Gas, pay of lamplighters, gas fitters, and laborers; purchase, erection, and repair of lamps and lamp-posts; purchase of matches and repairs of all kinds; stove, fuel, and lights for office and office stable, for watchmen's lodges, and for greenhouses at the nursery: *Provided*, That for each 5-foot burner not connected with a meter in the lamps on the public grounds not more than $20 shall be paid per lamp for gas, including lighting, cleaning, and keeping the lamps in repair, under any expenditure provided for in this act, and said lamps shall burn every night on the average from 45 minutes after sunset to 45 minutes before sunrise; and authority is hereby given to substitute other illuminating material for the same or less price, and to use so much of the sum hereby appropriated as may be necessary for that purpose	12,500.00	
For lighting 6 arc electric lights in Executive Mansion grounds, within the iron fence, 365 nights, at not exceeding 25 cents per light per night	547.50	
		13,047.50
Lighting public grounds, District of Columbia:		
For lighting 7 arc electric lights in grounds south of the Executive Mansion, 365 nights, at 20 cents per light per night	511.00	
For lighting 32 arc electric lights in Lafayette, Franklin, Judiciary, and Lincoln parks, 365 nights, at 25 cents per light per night	2,920.00	
For lighting 14 arc electric lights in grounds south of Executive Mansion and Monument Park, 365 nights, at not exceeding 25 cents per light per night	1,277.50	
		4,708.50
Repairs to water pipes and fire plugs:		
Repairing and extending water pipes, purchase of apparatus for cleaning them, purchase of hose, and for cleaning the springs and repairing and renewing the pipes of the same that supply the Capitol, the Executive Mansion, and the building for the State, War, and Navy Departments		2,500.00
Telegraph to connect the Capitol with the departments and the Government Printing Office:		
For care and repair of existing lines		1,500.00
United States wharf from north line of Arsenal Grounds to southern curb line of N street south:		
For cleaning up, clearing away, removing old buildings, piles, etc		5,000.00
Total		269,226.00

Washington Monument, elevator, electric lights, and machinery connected therewith.

The following estimate for operating the elevator, the electric lights, and the machinery connected therewith for the fiscal year ending June 30, 1902, is submitted:

1 custodian, at $100 per month	$1,200.00
1 steam engineer, at $80 per month	960.00
1 assistant steam engineer, at $60 per month	720.00
1 fireman, at $50 per month	600.00
1 assistant fireman, at $45 per month	540.00
1 conductor of elevator car, at $75 per month	900.00
1 attendant on floor, at $60 per month	720.00
1 attendant on top floor, at $60 per month	720.00
3 night and day watchmen, at $60 per month	2,160.00
For fuel, lights, oil, waste, packing, tools, matches, paints, brushes, brooms, lanterns, rope, nails, screws, lead, electric lights, heating apparatus, oil stoves for elevator car and upper and lower floors, repairs to engines, boilers, dynamos, elevator, and repairs of all kinds connected with the Monument and machinery, and purchase of all necessary articles for keeping the Monument, machinery, elevator, and electric-light plant in good order	3,000.00
Total	11,520.00

Financial statement for fiscal year ending June 30, 1900.

Title of appropriation.	Available at beginning of fiscal year.	Appropriated since.	Expended during fiscal year.	Pledged by contract.	Unexpended balance to revert to Treasury.
Improvement and care of public grounds, 1900	$76,150.00	*a* $1,000.00	$76,030.92		$1,119.08
Repairs, fuel, etc., Executive Mansion, 1900	46,000.00		42,996.60		3,003.40
Lighting, etc., Executive Mansion, 1900	13,047.50		12,999.95		47.55
Lighting public grounds, District of Columbia, 1900	4,708.50		4,612.44		96.06
Repairs to water pipes and fire plugs, 1900	2,500.00		2,497.60		2.40
Telegraph to connect the Capitol with the Departments and Government Printing Office, 1900	1,500.00		1,500.00		
Care and maintenance of the Washington Monument, 1900	11,520.00		11,276.85		243.15
Contingent expenses, public buildings and grounds, 1900	500.00		495.82		4.18
Salaries of employees, public buildings and grounds, 1900	51,520.00		50,927.34		592.66
Repair of building where Abraham Lincoln died, 1900	3,833.50		2,564.79		1,268.71
Purchase and repair of building where Abraham Lincoln died *b*	827.00				
Equestrian statue of Gen. William T. Sherman *b*	59,865.00	*c* 17,555.05	29,563.05	$39,000.00	
Pedestal for statue of Gen. John A. Logan *b*	16,499.21			16,500.00	
Lincoln tablet, Gettysburg National Park *b*	4,934.60				
Building for Government Printing Office, repairs and rent *b*	28,403.53				
Improvement and care of public grounds, 1900–1901		*d* 6,500.00	253.52		
Foundation for monument to Samuel Hahnemann *b*		*e* 4,000.00	1,239.56		
Electric plant, Washington Monument *b*		*d* 26,500.00			

a Joint resolution, March 19, 1900.
b Not a fiscal year appropriation.
c Deficiency acts of June 6, 1900.
d Sundry civil act, June 6, 1900.
e Joint resolution, January 31, 1900.

In addition to the important historical information contained in Appendix A to this report and previously described, there is also forwarded herewith, as Appendix B, a partial descriptive list of trees in a number of the parks under the jurisdiction of this office.

In conclusion I desire to express my sincere appreciation of the faithful services rendered during the past year by the entire force in the employment of this office, and particularly to renew my sincere appreciation of the efficient and voluminous work done by the landscape gardener, Mr. George H. Brown, and Mr. E. F. Concklin, overseer.

I am, General, very respectfully, your obedient servant,

THEO. A. BINGHAM,
Colonel, United States Army,
Major, Corps of Engineers.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

APPENDIX A.

LEGAL STATUS OF THE OFFICE OF PUBLIC BUILDINGS AND GROUNDS.

[Report on Senate bill 2725, Fifty-sixth Congress, first session.]

By act of July 16, 1790, section 2 (Stat. 1, p. 130), the President of the United States was "authorized to appoint, and by supplying vacancies happening from refusals to act or other causes, to keep in appointment as long as may be necessary three commissioners, who, or any two of whom, shall, under the direction of the President, survey, and by proper metes and bounds define and limit a district of territory under the limitations above mentioned," etc.

In performing their duties of course the said three commissioners employed surveyors to lay out the new city and establish the "metes and bounds" called for, of whom the first was Peter L'Enfant. (See list Appendix C). There was, however, only the General Government over the new city and nothing at all in the shape of a municipality or local government.

The act of May 1, 1802 (Stat. 2, p. 175), provides:

"SEC. 1. That from and after the first day of June next the offices of the commissioners appointed in virtue of an act passed on the sixteenth day of July, in the year seventeen hundred and ninety, * * * shall cease and determine, and the said commissioners shall deliver up unto such person as the President shall appoint, in virtue of this act, all plans, drafts, books, records, accounts, deeds, grants, contracts, bonds, obligations, securities, and other evidences of debt in their possession which relate to the city of Washington and the affairs heretofore under their superintendence or care.

"SEC. 2. *And be it further enacted*, That the affairs of the city of Washington, which have heretofore been under the care and superintendence of the said commissioners, shall hereafter be under the direction of a superintendent, to be appointed by, and to be under the control of, the President of the United States; and the said superintendent is hereby invested with all the powers and shall hereafter perform all the duties which the said commissioners are now vested with or are required to perform by or in virtue of any act of Congress or any act of the general assembly of Maryland, or any deed or deeds of trust from the original proprietors of the lots in said 'city or in any other manner whatsoever.'"

Section 3 provides for the three commissioners to settle with the Treasury and turn over balances to the superintendent.

Section 4 provides for the superintendent to pay debts contracted by the commissioners out of said balances and out of moneys arising "out of the city funds."

Sections 5 and 6 provide for the superintendent to go on selling lots, paying interest on loans, etc.

Here let it be observed how closely the control of everything connected with the new city is held in the hands of the General Government, as represented by the President of the United States and his appointee, the superintendent. There is no sign as yet of any purely local interest whatever being allowed a voice in the control of the new city.

Let it be observed again that the United States authorities in charge of the new city had surveyors under them who had been at work since 1790 making the surveys for the division of land and sales of lots, which last were going on with more or less activity during all this time.

The act of May 3, 1802 (Stat. 2, p. 195), incorporates the inhabitants of the city of Washington, giving them for the first time a voice in purely local matters, among which are:

"SEC. 7. * * * To erect and repair bridges; to keep in repair all necessary streets, avenues, drains, and sewers, and to pass regulations necessary for the preservation of the same, agreeably to the plan of said city."

Note here that all questions of laying out streets, etc., control of land, divisions and records, sales of land, etc., are still retained by the superintendent, acting for the General Government, and are not subject to any local official of the city corporation.

There is no hint in this act of any purely local or municipal "city surveyor," because none of the duties of such an official were delegated by the act of incorporation, inasmuch as they were already, and had since the beginning been, in charge of the superintendent of the General Government and the United States city surveyors under him.

Act of March 3, 1803 (Stat. 2, p. 235), calls the superintendent "superintendent of the city of Washington."

As said above, since the beginning of the city in 1790 United States surveyors were employed in laying it out under the commissioners and later under the superintendent, and these men were naturally called "city surveyors," and the act above quoted provides for the salary of the superintendent, calling him "superintendent of the city of Washington," and also for a salary for "city surveyor," who was the United States city surveyor under the General Government—that is, under the superintendent—because otherwise he would not have been appropriated for by Congress, but provided for as a municipal official by municipal taxation, as provided in the act of incorporation. This act of March 3, 1803, is the first official appearance of the title of "city surveyor," and applies, as shown, to an employee of the General Government and not to a purely local official.

In this entire discussion it is necessary to keep very clearly in mind that, except at the very beginning, the city of Washington has been under two governments—that of the General Government and that of the local or municipal—and that, while surveyors of the city have been employed from the beginning, a clear distinction has been preserved by Congress between those under the General Government and those under the municipal government, these latter being vested only with authority from the municipality and not from Congress, and their activity being limited to work on private property.

It has been claimed that since the city of Washington was empowered by the act of incorporation of May 3, 1802 (2 Stat., p. 192), to "provide for all municipal officers," that includes a "city surveyor." This act provides for a mayor and council, and says: "The mayor shall appoint to all offices under the corporation."

It has been shown that the duties of laying out "metes and bounds" and other similar work of a "city surveyor" were not committed to the corporation, whose authority thus far in that line was limited to repair of streets, etc., and as a matter of record the first municipal or local surveyor was not appointed until after 1815, and the actual work of laying out streets and dividing and selling off lots was continually being done by United States city surveyors under the General Government.

The act of February 24, 1804 (2 Stat., p. 254), alters somewhat the act of incorporation of the city of Washington, and indicates the powers of the council. These all refer to local matters, and in part read "to provide for the appointment of * * * and such other officers as may be necessary to execute the laws of the corporation." But there is no hint of a municipal "surveyor," and Congress was so jealous of any local authority whatsoever that the last section of this act deprived the levy court of the county of Washington of the power of imposing any tax on the inhabitants of the city of Washington.

We now come to the act of January 12, 1809 (2 Stat., p. 511), relating to subdivision of squares and lots and the recording of same. Here the "surveyor of the city" is much talked of, and because of that wording it is claimed he was the municipal surveyor, whereas he was the "surveyor of the city" for the United States Government and a subordinate of the superintendent, as shown by what has been said above.

Section 7 of said act provides—

"That all records of the division of squares and lots heretofore made between the public and original proprietors, or which are authorized by this act, shall be kept in the office of surveyor of the city; and all transcripts therefrom certified by him shall be evidence equally valid with certified transcripts from the keeper of the office for recording deeds for the conveyance of land in the county of Washington."

Now, as shown so clearly above, this "surveyor of the city" was not a local or municipal surveyor, working under the city corporation, but a United States surveyor of the city of Washington, working under the superintendent and, above him,

under the President of the United States himself. There was no attempt to have a municipal or local city surveyor until six or more years later. But because of the purely accidental similarity of names it has been argued that because this act specifically says the land records, etc., shall be put in charge of the (United States) surveyor of the city, therefore this was the establishment of a new office of local or municipal or city surveyor, as opposed to the United States city surveyor. This argument is contrary to historical fact.

The records of the three original commissioners, beginning with 1790, of the city show the existence of a recorder of deeds (who was also the clerk to the commismissioners) as well as of a United States surveyor of the city. From the very beginning, in 1790, as land began to be divided up and sold off, each separate square was drawn upon a large sheet of paper, the square then divided into lots, and on the division of lots between the public and the original proprietors both parties and their witnesses signed the division thus made of that square. Three copies of each division were so signed. One copy was kept by the commissioners as representing the United States. A second copy was given to the original proprietors as representing themselves. The third copy was given to the recorder of deeds for the use of private owners.

Now, the effect of the act of January 12, 1809, was to establish the United States surveyor of the General Government as the future guardian of such maps instead of the recorder of deeds, as had previously been the case, both being United States officials. But there is no sign yet of any local or municipal surveyor or of any division of the authority of Congress and the General Government in the matter of city surveys. It is these maps, specially intrusted to the guardianship of the United States surveyor by Congress in 1809, and regularly transmitted by authority of law to the Chief of Engineers of the Army to-day, and on which rest all the title of the United States to its various properties in the city of Washington, that the bill under discussion proposes to hand over to a subordinate official of the purely local government of the city.

As will appear in the sequel, owing to the legal doubt of the city corporation having any authority to have a corporation surveyor, the United States city surveyor often did the work found necessary by the corporation on private land, and there were several cases where the same man held both offices, and thus it happens that to-day the corporation surveyor has in possession one of the original copies of division of squares, viz, the set which was originally set aside for the use of owners of private property in this city.

We next come to that point in this history where the municipal or purely local so-called "city surveyor" first puts in an appearance; and let it not be forgotten that there was already in existence, since 1790, the regular United States city surveyor, under the superintendent for the General Government, which official, or his legal successors, exists to-day by authority of Congress, as will appear in the sequel. In 1815 the city corporation felt the need of a local surveyor for purely local work on private property. Benjamin H. Latrobe was appointed September 5, 1815, as the first municipal "city surveyor." So little authority had the local corporation to appoint a corporation city surveyor that Latrobe was appointed by the United States superintendent of the city, as one of his letters proves.

The records of that time show there was so much doubt even then of proper authority in the corporation to make an appointment of a local city surveyor, and that, although such appointments were made in succeeding years, so late as July 7, 1826, a joint resolution of the city council was passed reciting that the circuit court of the county of Washington had called in question the authority of the municipal surveyor so appointed, and asking the President to appoint such municipal surveyor. A good deal of argument about the existence of a municipal surveyor of about this time has been made, but is based wholly on acts of the corporation, a purely local body, and having no authority whatever to affect the United States city surveyor, nor does a study of the records show that they had such intention.

Somewhere between 1826 and 1836 the first legal existence of a local city surveyor was established, for the act of July 4, 1836 (Stat. 6, p. 683), recognized such an official. While a few of the local interests of the city of Washington were thus, in 1815-16, administered by a mayor and corporation, and they were by no means sure of their authority to appoint a local or municipal surveyor, a change was made by Congress in the method of administering the authority of the General Government.

By act of April 29, 1816, section 5 (3 Stat., p. 324), it was enacted:

"That from and after the third day of March next the office of superintendent, established by act of Congress of first May, one thousand eight hundred and two, shall cease, and thereafter the duties of said office shall be performed by the commissioner to be appointed by virtue of this act (sec. 2), and to whom the superin-

tendent shall deliver all documents, securities, books, and papers relating to said office; and from and after the third of March next the commissioner aforesaid shall be vested with all the powers and perform all the duties conferred upon the superintendent aforesaid."

This is the third step in the succession from the original commissioners of 1790 to the Chief of Engineers at present; and here it is to be noted that the original commissioners of 1790 had charge of everything—surveys, sales, laying out streets, erecting buildings, etc.—and transferred all this work to the superintendent. As public building became extensive, that part of his work was for several years devolved upon separate commissioners, leaving the superintendent mainly surveying work. But now, by the law above quoted, section 2, act of April 29, 1816 (3 Stat., p. 324), it is enacted—

"That so much of any act or acts as authorizes the appointment of three commissioners for the superintendence of the public buildings be, and the same is hereby, repealed; and in lieu of the said commissioners there shall be appointed by the President of the United States, by and with the advice and consent of the Senate, one commissioner, who shall hold no other office under the authority of the United States, and who shall perform all the duties with which the said three commissioners were charged, and whose duty it shall also be, etc."

Here we see, then, the offices of public buildings and of public grounds reunited as it had begun in 1790.

Carrying out the legal succession of the commissioner of public buildings and grounds, the next step is the sundry civil act of March 2, 1867, section 2, (14 Stat., p. 466), which reads:

"That the office of commissioner of public buildings is hereby abolished; and the Chief Engineer of the Army shall perform all the duties now required by law of said commissioner, and shall also have the superintendence of the Washington Aqueduct and all the public works and improvements of the Government of the United States in the District of Columbia, unless otherwise provided by law."

We have seen how doubtful was the authority of a municipal city surveyor so late as 1826. The act of July 4, 1836 (6 Stat., p. 683), recognized such a local official.

The act of May 17, 1848 (9 Stat., p. 228), alters the charter of the city of Washington, and provides (sec. 4) for the election of a (municipal) city surveyor. The last sentence of section 8 says, "and the office of the surveyor of the city of Washington shall be the legal office of record of the plats of all property in the city of Washington."

From this it has been argued that Congress intended to give up all the land records of the General Government to the (municipal) city surveyor—a local official elected by those who happened to live in Washington. That supposition would be of itself open to grave doubt. But the first part of the same section 8 provides: "That the said corporation shall have power to cause to be made out plats of all the squares in the city of Washington, on which shall be shown the lines of all the subdivisions of said squares as the same shall actually exist at the date of completion of the plat of each square and to prescribe and regulate the manner in which description shall be made of all real estate sold or transferred in the said city," and then provides the scale on which said plats shall be drawn.

Now, why compel the corporation to make out their own maps if their municipal surveyor had or was to have charge of all the land records of Washington from the beginning? That the intention of Congress was that the city surveyor provided for by this act should be solely a local official and should make for the use of private land owners such maps as were needed, separate from those of the General Government, is, however, clearly shown by section 12 of the same act, providing: "That the commissioner of public buildings, or other officer having charge and authority over the lands and property of the United States lying within the city of Washington, shall from time to time cause to be opened and improved such avenues and streets, or parts or portions thereof, as the President of the United States, upon application of the corporation of the said city, shall deem necessary for the public convenience and direct to be done;" and further directs money from sale of lots to be used for such purposes and for the repair of streets, avenues, etc., thus clearly showing that all the Government lands of the city, including streets, were kept in charge of an official of the General Government (and this must include the records showing title), and thus practically limiting the municipal city surveyor to charge of lands belonging to private citizens and the records pertaining to said private lands.

By section 13 of this same act the commissioner of public buildings is charged with the duties of city commissioner in removing nuisances, showing again how Congress kept in the General Government and kept away from the local government things which might be thought of purely local interest if Congress had not so specifically expressed itself. It is not reasonable to suppose on the above evidence that

the municipal city surveyor had taken the place of the United States city surveyor over matters which, all the evidence shows, Congress had from the very beginning jealously retained in charge of officials of the General Government.

Act of February 21, 1871 (16 Stat., p. 419), changes the form of local government of the District to a governor, legislative assembly, and board of public works, but no mention is made of anything of interest in this discussion except to note that the local government is given authority and compelled to repair streets, avenues, etc.

Act of June 20, 1874 (18 Stat., p. 116), again changes the local form of government to three Commissioners, one of them an engineer officer of the Army. He succeeds to the duties of the chief engineer of the former board of public works and to the guardianship of all such maps and records as the board of public works had. Moreover, the local city surveyor is regarded as of so little importance that he is reduced to taking fees in compensation for special services, and assistant surveyors are abolished. Note that all this while the office of public buildings and grounds is in existence as from the beginning and the surveyor employed by it is still the only United States city surveyor.

Act of June 11, 1878 (20 Stat., p. 102), establishes the present local form of government of the District, and since one of the Commissioners is an engineer officer of the Army no local or corporation city surveyor is mentioned at all in the law. The Commissioners have found it necessary to have such an official for purely local work on private property, but he is merely an appointment by the Commissioners, so that the local or corporation city surveyor is an office not recognized by any act of Congress now in force.

1. In view of the preceding, it is clear that now for one hundred and ten years Congress has carefully kept in the custody of the General Government all the records of the national capital except those pertaining to purely private land. Congress has remembered that this is the capital city of the whole nation and has for over a hundred years carefully kept the policy of its growth within its own hands, jealously preventing purely local interests from getting control of the nation's city.

2. The transfer of records proposed by this bill[1] would seriously endanger the interest of the United States by depriving them of the records on which rest the titles of the United States to its various properties in the city of Washington, including the very streets. It would be like depriving an owner of property of his deed and other evidences of title thereto, and surely tbe United Staies ought to be able to preserve its own proofs of possession.

Had these records not been kept in the possession of the General Goverment it is not impossible the United States would have been unable to prove its title in the great Potomac Flats case recently decided by the Supreme Court in its favor.

3. Nor is such a transfer at all needed by circumstances, for one copy of the original division of squares is or should be in the possession of the local surveyor (see page 5 of this report). Errors which have from time to time been claimed in them can not be corrected from any of the other originals because they are identical, and, as a matter of fact, it has turned out in the past that a few of the squares which it was sought to correct had no existence, and others had never been divided, for which very sufficient reason they had never been recorded. Moreover, these United States records have been and are still easily accessible to all proper examination for legitimate business, although not to parties whose wish to examine them is not altogether legitimate, which class is not a stranger to the custodian of these records.

4. Again, the custody of these records for the United States by the Chief of Engineers of the Army is a great protection to the interests of private land owners as well; because records so kept by the General Government are a check against the possibility of fraud in the land records of the city of Washington and District of Columbia—attempts at which are not unknown in the past; and, as shown above, all the records needed for ordinary daily use are now available for the general public in the office of the local surveyor.

5. The transfer proposed by the bill would endanger the safety of the records themselves, which can never be replaced. They are stored by themselves in a separate room of the War Department, one of the safest buildings in the world against fire or theft; and when the room is open there is always an official present there.

Section 2 of the bill does not of itself provide the safety it calls for, which can not be greater than it is at present, where the records are also as accessible to proper examination as they can be made anywhere; and also where they are in the personal charge of a gentleman who is more intimately acquainted with them and knows more about them than anyone now living, and who is available to assist in reference to them as no one else can. The gentleman referred to is Capt. John Stewart, C. E.,

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[1] Senate bill 2725, Fifty-sixth Congress, first session.

an able, faithful, efficient, and valued employee of the United States for over twenty-five years past.

6. In this case, again, as happens so often in Washington, it is the interests of the General Government that should primarily be considered and not merely local interests. For this is not any ordinary municipality, it is one city out of all the country; it belongs to the people at large and the interests of all the other people of the United States must overbalance the purely local desires of the few who actually live in Washington. There has been in the past carelessness in work done and records kept in the District of Columbia, as almost any antiquarian knows from his researches. How else have valuable collections been bought and paid for by the United States containing many papers and records which have always belonged to the United States, but which disappeared somehow and had to be bought in order to regain possession of them? As said above, there was a period of, roughly, forty years—from about 1830 until the close of the civil war—when the offices of United States city surveyor and of the local or corporation surveyor were held by one and the same man, during which time the United States records were very carelessly handled, and it is in this way that many of the United States records passed into improper hands from which they have not yet all been regained.

The famous Tin Case Map was found by one of the commissioners of public buildings and grounds in the office of Mayor Force, and formed the subject of correspondence before it was returned. It was the salvation of these records when they were placed in charge of the Chief of Engineers, United States Army. A system for their care was adopted and carried out under the Chief of Engineers. These records have been classified, partially indexed, and examined and arranged, so that it is now known what is missing. Some of the missing records have been traced and obtained, others traced to the collections of Dr. Toner, Mr. Peter Force, and the Oldest Inhabitants' Society; and, strangest of all, some are known to be in the possession of the local city surveyor, without proper authority. They got there originally under the régime which formerly prevailed as above stated, but it is not known by what claim they remain there.

Finally, it seems undoubted that it is to the best interests of the General Government that the records referred to should remain in their present keeping and moreover be completed by the restoration of what is missing, so far as it can be traced.

Should Congress in its wisdom deem best, however, to direct local rather than United States custody for these records, it is respectfully suggested that the Engineer Commissioner of the District is a more appropriate custodian than a subordinate appointee of the District Commissioners; because Congress would then have double security, for the Engineer Commissioner is not only a member of the Board of District Commissioners, and appointed thereto by the President of the United States, but he is also an officer of the Corps of Engineers of the Army. It might well be asked, though, why he should be more trusted as custodian than the Chief of Engineers himself.

In conclusion, should it be so desired, it would give me pleasure to appear before the committee and give them further information about these and other details connected with this matter which can be communicated better orally than in writing.

Particular attention is called to the three summaries appended hereto.

Theo. A. Bingham,
Colonel, U. S. A., Major, Corps of Engineers.

Office Public Buildings and Grounds,
Washington, D. C., March 6, 1900.

Appendix 1.

LINE OF LEGAL EXISTENCE OF OFFICE OF PUBLIC BUILDINGS AND GROUNDS.

By act of July 16, 1790 (Stat. 1, p. 130), section 2, the President of the United States was "authorized to appoint and, by supplying vacancies happening from refusals to act or other causes, to keep in appointment as long as may be necessary, three commissioners, who, or any two of whom, shall, under the direction of the President, survey, and by proper metes and bounds define and limit a district of territory under the limitations above mentioned, etc.

In performing their duties, the said three commissioners employed surveyors to lay out the new city and establish the "metes and bounds" called for.

The first United States city surveyor was Peter Charles L'Enfant, appointed January 22, 1791. The second was Andrew Ellicott, appointed same date. The third was Nicholas King, appointed September 21, 1796. The fourth was Robert King, sr., appointed September 12, 1797. By act of May 1, 1802 (Stat. 2, p. 175).

"From and after the first day of June next, the offices of the commissioners appointed in virtue of an act passed on the sixteenth day of July in the year seventeen hundred and ninety * * * shall cease and determine; and the said commissioners shall deliver up unto such person as the President shall appoint in virtue of this act, all plans, draughts, books, records, accounts, deeds, grants, contracts, bonds, obligations, securities, and other evidences of debt in their possession which relate to the city of Washington and the affairs heretofore under their superintendence or care."

"SEC. 2. *And be it further enacted*, That the affairs of the city of Washington which have heretofore been under the care and superintendence of the said commissioners shall hereafter be under the direction of a superintendent, to be appointed by, and be under the control of the President of the United States; and the said superintendent is hereby invested with all the powers, and shall hereafter perform all the duties which the said commissioners are now vested with, or are required to perform by, or in virtue of any act of Congress, or any act of the general assembly of Maryland, or any deed or deeds of trust from the original proprietors of the lots in said city, or in any other manner whatsoever."

Under the superintendent thus provided the fourth United States city surveyor, Robt. King, sr., was continued.

The fifth was Nicholas King, appointed June 1, 1803.

The sixth was Robt. King, jr., appointed September 5, 1815.

The act of March 3, 1803 (Stat. 2, p. 235), calls this superintendent "Superintendent of the city of Washington," and provides for his salary and also for the United States "city surveyor" under him.

By act of April 29, 1816, section 2 (Stat. 3, p. 324), "so much of any act or acts as authorizes the appointment of three commissioners for the superintendence of the public buildings be, and the same is hereby, repealed; and in lieu of the said commissioners, there shall be appointed by the President of the United States, by and with the advice and consent of the Senate, one commissioner, who shall hold no other office under the authority of the United States, and who shall perform all the duties with which the said three commissioners were charged." * * *

Section 5 of same act says "from and after the third day of March next, the office of superintendent, established by act of Congress of first of May, one thousand eight hundred and two, shall cease, and thereafter the duties of said office shall be performed by the commissioner to be appointed by virtue of this act (sec. 2), and to whom the superintendent shall deliver all documents, securities, books, and papers relating to said office; and from and after the third of March next the commissioner aforesaid shall be vested with all the powers and perform all the duties conferred upon the superintendent aforesaid."

This brings together again, as they had begun in 1790, the offices of public buildings and grounds.

The sixth United States city surveyor, Robert King, jr., was continued.

The seventh United States city surveyor was F. C. De Krafft, appointed June 1, 1822, who thus continued until—

Act of July 4, 1836 (Stat. 6, p. 683), shows that he became city surveyor under the corporation.

The United States city surveyor was Randolph Coyle, appointed April 20, 1851.

By act of March 2, 1867, section 2 (Stat. 14, p. 466): "The office of commissioner of public buildings is hereby abolished; and the Chief Engineer of the Army shall perform all the duties now required by law of said commissioner, and shall also have the superintendence of the Washington Aqueduct and all the public works and improvements of the Government of the United States in the District of Columbia, unless otherwise provided by law."

General Michler, Corps of Engineers, U. S. A., was ordered by the Chief of Engineers, in accordance with the above law, to undertake this duty under the Chief of Engineers. Although no mention of transfer of papers, maps, etc., occurs in the law, of which fact an argument has been made, it never occurred to anyone to question the right of General Michler to take possession of the office and of all the records belonging to it and handed down by past commissioners, which he did. Nor is it to be supposed that such a violation of the intent of Congress, had it wished it otherwise, would have been allowed to pass unnoticed any more than it would to-day.

Under the Chief of Engineers and General Michler, Capt. John Stewart, C. E., was appointed United States city "surveyor" September 18, 1873, and has so continued to this day.

Appendix 2.

LINE OF LEGAL EXISTENCE OF PURELY LOCAL GOVERNMENT OF THE CITY OF WASHINGTON AND OF A LOCAL "CITY SURVEYOR."

Act May 3, 1802 (Stat. 2, p. 195), establishes the first city corporation, but makes no mention of a corporation city surveyor.

Act of February 24, 1804 (Stat. 2, p. 254), amends the corporation, but makes no mention of corporation surveyor.

Act of July 4, 1836 (Stat. 6, p. 683), shows the corporation had power to appoint a corporation surveyor.

Act of May 17, 1848 (Stat. 9, p. 228), alters the city charter, and the corporation city surveyor is made elective. But (as shown on page 9) he is clearly for local and private property.

Act of February 21, 1871 (Stat. 16, p. 419), the form of city government is changed to the so-called "board of works."

Act of June 20, 1874 (Stat. 18, p. 116), the form of city government is again changed to a board of three commissioners, one of whom is to be an officer of the Corps of Engineers, United States Army. At the same time the local "city surveyor" is practically abolished, he being reduced to compensation only by fees for special services, and the assistant local surveyors are abolished.

Act of June 11, 1878 (Stat 20, p. 102), the form of city government is reorganized under three commissioners, one of whom shall be an engineer officer of the Army. No mention is made of a local or corporation "city surveyor." This proviso is, however, distinctly made (Stat. 20, p. 104): "*Provided*, That nothing herein contained shall be construed as transferring from the United States authorities any of the public works within the District of Columbia now in the control or supervision of said authorities."

Appendix 3.

UNITED STATES, OFFICE OF PUBLIC BUILDINGS AND GROUNDS.

Office held by—	United States city surveyors.	When appointed.
Three commissioners, act July 16, 1790 (Stats. 1, p. 130).	P. C. L'Enfant, C. E	Jan. 22, 1791.
	Andrew Ellicott	Do.
	Nicholas King	Sept. 21, 1796
	Robt. King, sr	Sept. 12, 1797.
One superintendent, act May 1, 1802 (Stats. 2, p. 175).	.....do	Continued.
	Nicholas King, d. May, 1812.	June 1, 1803.
	Robt. King, jr	May 21, 1812, to Mar. 14, 1815.
	Robt. King, jr., by new commission.	Sept. 5, 1815.
One commissioner, act Apr. 29, 1816 (Stats. 3, p. 324).	Robt. King, jr	Continued.
	F. C. De Krafft	June 1, 1822.
	.....do. *a*	Aug. 13, 1828.
	Randolph Coyle, C. E	Apr. 20, 1851.
Chief of Engineers, act Mar. 2, 1867 (Stats. 14, p. 466).	John Stewart, C. E	Sept. 18, 1873, to date.

a Continued till the act of July 4, 1836 (Stats. 6, p. 683); shows that Surveyor De Krafft left office of public buildings and became surveyor of the city under the corporation.

MUNICIPAL GOVERNMENT.

Carried on by—	Local surveyors.	Appointed.
First corporation, act May 3, 1802 (Stats. 2, p. 195).	Benj. H. Latrobe	Sept. 5, 1815, by United States superintendent.
	Joseph Elgar	May 3, 1817.
	F. C. De Krafft	Aug. 13, 1828.
	Wm. Elliot	June 1, 1832.
	W. P. Elliot (son)	June 1, 1837.
	Randolph Coyle	June 1, 1846.
	C. B. Clusky	June 1, 1848.
	Wm. H. Ball	June 1, 1851.
	E. F. Hunt	July 1, 1855.
	Wm. Forsyth	July 1, 1857.
	Charles Bliss	July 1, 1868.
	P. H. Dinegan	July 1, 1870.
"Board of works," act Feb. 21, 1871 (Stats. 16, p. 419).	Wm. Forsyth	July 1, 1871.
Three commissioners, act June 20, 1874 (Stats. 18, p. 116).	John Partridge	July 1, 1877.
Three commissioners, act June 11, 1878 (Stats. 20, p. 102).	Wm. Forsyth	July 1, 1881.
	Henry B. Looker	Aug. 16, 1897.

WAR DEPARTMENT,
Washington, March 8, 1900.

SIR: In response to the request contained in your letter of the 19th ultimo I have the honor to transmit herewith a list showing the nature of papers and documents forming a part of the early records of the city of Washington, now in the custody of the Chief of Engineers, United States Army.

Very respectfully,

G. D. MEIKLEJOHN,
Acting Secretary of War.

Hon. JAS. McMILLAN,
Chairman Committee on the District of Columbia, United States Senate.

List showing the nature of papers and documents forming a part of the early records of the city of Washington, now in the custody of the Chief of Engineers, United States Army.

Journal No. 1, beginning October 17, 1791.
Journal No. 2.
Journal No. 3.
Journal No. 4.
Journal No. 5.
Journal No. 6.
Journal No. 7, ending May 10, 1851.
Original proprietors' accounts and division of squares, 1791–1796.
Index of squares recorded on division by the Commissioners, 1791–1802.
Redivision of city lots in Carrollsburg and Hamburg, 1790–1791.
S. B. account of divisions with original proprietors and the Commissioners, 1791–1798.
Account of divisions with original proprietors by the Commissioners, 1794–1799.
Sales of lots under direction of Commissioners, 1791–1802.
Sales of lots under direction of Commissioners, 1792–1800.
Selection of lots by Greenleaf, Morris, and Nicholson, 1794–1797.
Record of certificates for lots sold by the Commissioners, 1795–1802.
Divisions of squares with original proprietors, 1791–1804.
Calculations and original proprietors' account with the Commissioners, 1794–1809.
Appropriation book, 1849–1853.
Cashbook, 1851–1853.
Cashbook, 1853–54.
Cashbook, January 9, 1855, to June 30, 1855.
Cashbook, July 7, 1855, to November 28, 1857.
Journal, 1857–1861.
Journal, September 16, 1861, to December 31, 1861.
Ledger, 1854–1856.
Ledger, 1861–1867.
Ledger, March, 1867.
Requisition book, 1856–1860.
General ledger, 1791–1794.
General ledger, 1795–1816.
General ledger, 1815–1833.
General ledger, 1834–1846.
General ledger, 1836–1841.
General ledger, 1841–1846.
General ledger, 1846–1850.
General ledger, 1851–1853.
General ledger, 1853–1855.
General ledger, 1855–1860.
General ledger, 1859–1861.
General ledger, 1861.
General ledger, 1861–1865.
General ledger, 1866–67.
Letters of commissioners of public buildings, 1791–1793.
Letters of commissioners of public buildings, 1793–1795.
Letters of commissioners of public buildings, 1795–1797.
Letters of commissioners of public buildings, 1797–98.
Letters of commissioners of public buildings, 1798–1800.
Letters of commissioners of public buildings, 1800–1802.
Letters of commissioners of public buildings, 1815–1833.

Letters of commissioners of public buildings, 1836–1839.
Letters of commissioners of public buildings, 1838–1840.
Letters of commissioners of public buildings, 1851–1853.
Letters of commissioners of public buildings, 1853–1855.
Letters of commissioners of public buildings, 1855–1861.
Press letters, 1861–62.
Press letters, 1861–1865.
Press letters, 1864–1866.
Press letters, 1864–1867.
Press letters, 1866–67.
Press letters, 1867–68.
Press letters, 1868–1870.
Press letters, December 2, 1870, to December 8, 1870.
Press letters, January 23, 1871, to November 2, 1871.
Index of letters sent.
Index of letters received.
Commissioners' proceedings, 1791–1795; missing from April 2, 1795, to October 24, 1796.
Commissioners' proceedings, 1796–97.
Commissioners' proceedings, 1797–98.
Commissioners' proceedings, 1798–1800.
Commissioners' proceedings, 1800–1802.
Commissioners' proceedings, 1815–16.
Commissioners' proceedings, 1838–1840.
Index of commissioners' proceedings, 1791–1802.
List of lots remaining unsold in the years 1822, 1834, 1849, 1864, and 1865.
Report of Robert Ould on city lots, 1853–1855.
File book, deeds, chancery decrees, etc., in reference to sale of lots.
Plans and deeds of square south of 1001, navy-yard bridge.
Report on sale of public lots (incomplete), 1895.
Instruments signed by Presidents Washington and Adams, approving the so-called Dermott plan of the city of Washington, 1797–98.
Soundings of Potomac River, 1795–96.
Official letters received, 1791–1867.
Accounts sales of lots, 1 package.
Advertisements for same, 1 package.
Agreements for squares and lots, 1 package.
Assignations of lots, 1 package.
Bonds, powers of attorney, and receipts for lots, 1 package.
Deeds for lots, 1 package.
Division of lots, 1 package.
Fourteen books containing copies of letters of the original commissioners, 1792–1798.
Bank account books Commissioners French and Blake, of public buildings and grounds, 1854–1860.
Washington City Plat Book, volume 1, by Williams, squares 1–1170.
Check stubs, 1815–1869.
Permits for opening avenue and streets for laying pipe, 1859–1861.
Abstract of notes deposited in bank, 1838.
Receipted accounts, 1793–1867.
Original (division) records of squares 1 to 1099, inclusive, except 700–799, which are missing.
Deeds of conveyance from original proprietors of Carrollsburg and Hamburg.
Deeds of exchange for Carrollsburg and Hamburg.
Affidavits relative to workmen at Treasury building, 1840.
Canceled checks, 1851–1866.
Certificates of deposit, 1863–1866.
Comptrollers' settlements of account, 1820–1867.
Contracts, 1791–1866.
Estimates for repairs, materials, etc., 1816–1866.
Proposals, 1795–1866.
Plan of city of Washington, by L'Enfant, 1791.
Part of the above from which the first sale of lots was made, copied by J. R. Dermott, 1791.
Engraved (Philadelphia) plan of Washington, copied from L'Enfant, 1792.
Engraved (Boston) plan of Washington, copied from Ellicott's plan, 1792.
Part of plan of Washington, showing Funkstown or Hamburg, by J. R. Dermott, 1793.

Part plans of Washington, showing water lots and Water street from K street north to Twenty-fifth street east—12 streets, 1797.

Approved map of Washington, by J. R. Dermott, made in 1795; approved by President Washington in 1797 and by President Adams in 1798, 1795–1798.

Plan of wharves at square 503 and at square south of 1001, by N. King, 1797.

Map of Washington, by N. King; no date, probably 1797.

United States navy-yard reservation, 1799.

Plat of ground west of present Botanic Gardens; no date, probably 1802.

King portfolio map, 1872.

Plan of grounds adjacent to Capitol, 1822.

Copy by W. P. Elliot of the King portfolio map, 1836.

Maps of Kalorama, showing first boundary stone; no date.

Section of city map between Sixth and Fifteenth streets west, the canal, and north D street.

Plan for arching Tiber Creek through Botanic Gardens, 1864.

Forsyth's map of Washington, 1870.

Section showing original bed of Baltimore and Potomac Railroad passing the canal at reservation No. 17, 1874.

Copy by engineer department of No. 2 plan of parts of city of Washington, showing water lots and Water street along the Potomac from E to T streets south, by William Elliott, date 1835, 1868.

Portfolio map of real estate in county of Washington, 1881.

Portfolio map of squares in Georgetown.

Portfolio map of public reservations in Washington, by William Forsyth, 1883.

Copy of plat showing how the large 1793–1795 map now in local surveyor's office can be formed into a full map, 1891.

Map of square donated by Congress to Baltimore and Potomac Railroad, approved January 9, 1891.

DEPARTMENT OF STATE,
Washington, February 13, 1900.

DEAR SIR: I have the honor to acknowledge the receipt of your request of the 19th instant.

I will, with pleasure, cause to be prepared the list you desire of papers covering the early administration of affairs of the Federal District. The only matter of that character to be found here, however, is contained in the papers of General Washington and of Thomas Jefferson. Of the successors to the first commissioners or of the superintendent of public buildings and grounds there is nothing.

I have the honor to be, sir, your obedient servant,

JOHN HAY.

Hon. JAMES MCMILLAN,
Committee on the District of Columbia, United States Senate.

DEPARTMENT OF STATE,
Washington, March 14, 1900.

SIR: In further response to your letter of the 19th ultimo I have now the honor to inclose for your information a general list of papers and documents on file in this Department relative to the affairs of the Federal District and the city of Washington.

I have the honor to be, sir, your obedient servant,

JOHN HAY.

Hon. JAMES MCMILLAN,
United States Senate.

Package No. 1.—January 22, 1791, to March 15, 1793, 16 letters to Jefferson from Dan. Carroll, R. Brent, I. Fenwick, Notley Young, Geo. Walker, Chas. Wintersmith, L'Enfant, Thos. Harwood, S. Blodgett, J. Ambler, in re appropriation of land for Federal District. L'Enfant's arrogant conduct and dismissal. Plan of Capitol. Plan and map of city. Maryland loan; Virginia loan. [Stephen Hallet seeks appointment as architect.]

Package No. 2.—September, 1802, to 1816, 10 letters to Thomas Monroe, superintendent of the city of Washington, from John T. Mason, Lenthall, Blagden, Nick.

King, Dan. Carroll et al., Robt. Brent, A. Gallatin, Latrobe, Wash. Boyd et al., in re funds, building regulations, plan of Pennsylvania avenue, site of theater, estimate south wing of Capitol. Mark Crowley and Timothy King, laborers; progress on Capitol, erection of new court-house, etc.

Package No. 3.—January 20, 1792, to January 5, 1802. Forty-eight letters from the Federal District Commissioners to Greenleaf, Morris & Nicholson, L'Enfant, Benjamin and Andrew Ellicott, William Rhodes, John Johnson, managers canal lottery, Beall & Gantt, Alexander Hamilton, Charles Lee, William Thornton, —— Deakins, Alex. White. George Walker, legislatures of Maryland and Virginia, governor of Virginia, in re contracts for sale of plots, bonds, building regulations, liquidations of loans, loans from Maryland and Virginia, site of public buildings, L'Enfant's salary, map of District, canal, lottery, deed of trustees, etc., to District, resignation of L'Enfant, Slander *v.* Commissioners.

Package No. 4.—November, 1790, to June 5, 1802. Thirteen letters and 3 maps to the President from William Deakins, jr., Deakins & Stoddart, Francis Deakins et al., Andrew and Benjamin Ellicott, R. King, T. Briggs, John Hopkins, Samuel Davidson, in re surveys, platting, eminent domain, mismanagement of building, accounts, salaries, conduct of Dermott, of Ellicott, Ellicott's errors in surveying, loan from Virginia, maps in re location of Capital near Monocacy, near Williamsport.

Package No. 5.—June 19, 1802, to July 22, 1816, 61 letters. Thomas Monroe, superintendent, to the President, in re platting, sale of lots, erection and location of public buildings, condition of District treasury, state of loans from Maryland and Virginia, streets, bridges, progress of work, laborers, etc.

Package No. 6.—January 7, 1792, to July 23, 1816, 20 letters. Miscellaneous, in re site of Federal city, instructions to Roberdeau, Ellicott's charge against Dermott, quarries, appropriations for public buildings, conveyances to Federal District, Statue of Liberty, plan of city, observatory, L'Enfant's dismisssal, etc.

Package No. 7.—To the President. Eleven memorials, in re appointment of justices of the peace, building restrictions, highways, etc.; 4 papers: Return of votes on election of common council of Washington, 1800; expiration of term of justices of levy court, 1813; expiration of term of Mayor Brent, 1809; size of President's barn.

Package No. 8.—July, 1816. By James Madison, memorandum, in re site of new court-house. July, 1816. By Richard Rush, memorandum, in re site of observatory.

Package No. 9.—December 10, 1791, to March 28, 1801. Thirty letters to the Commissioners of the Federal District from Andrew and Benjamin Ellicott, Thomas Beall, and John M. Gantt, managers of canal lottery, Greenleaf, Morris & Nicholson, George Fenwick, William O. Neale, Samuel Davidson, William and Jan Willink, Uriah Forrest, J. Lingan, Robert Peter, Thomas Freeman, George Walker, in re canal, canal lottery, deeds and conveyances of land, surveys and surveying, Charges *v.* Dermott site of Capitol, change in plat of "President's square," European loan, sales of lots, Greenleaf's contract, Maryland loan, etc.

Package No. 10.— ——— to June 2, 1802. Seven letters from Jefferson to Ed. Randolph, L'Enfant, Carroll, "C. C.," Washington, David Ross, Colonel Hooe, R. King, in re site of Federal city, L'Enfant's services, form of conveyance, auditing Commissioners' accounts, progress of surveys.

Package No. 11.—January 27, 1791, to June 1, 1802. One hundred letters to the President and Secretary of State from the Commissioners of the Federal District, Dan. Carroll, Alex. White, William Thornton, Thomas Johnson, in re conveyances, cessions, sales and terms of sales, surveys, plats and maps, loans and interest, accounts, funds, salaries, laborers and importation of laborers, appointment of commissioners and of superintendent; Benjamin and Joseph Ellicott, L'Enfant, Roberdeau, Boaraff, Briggs, their conduct, resignation, or dismissal; lottery, canal, bridge, wharves, trees, shore boulevard, Goose Creek, Rock Creek, location of buildings, building restrictions, plan of Capitol, removal to Federal City, and surrender of office of Commissioners, etc.

Package No. 12.—190 papers. Proclamations, Executive orders, memoranda, contracts, bonds, deeds, certificates of title, prints, legal opinions, reports of work (chiefly by James Hogan), in re lotteries, loans, sales of lots, building regulations, eminent domain, public buildings, surveys, bridge, establishment of bank, removal of Federal Government, acts of Maryland and Virginia, celebration of July 4, public funds, etc.; list of houses in Washington, contracts, estimates, statements of accounts and of expenditures (chiefly by J. B. Latrobe, John Lenthall, and Thomas Monroe).

Package No. 13.—February 3, 1791, to May 7, 1798. Nineteen letters from Washington to Benjamin Stoddart, Deakins & Stoddart, L'Enfant, the Attorney-General, Jefferson, Uriah Forrest, governor of Maryland, David Burns, Thomas Law, in re dispute between L'Enfant and Commissioners, dispute between Ellicott and Commissioners, dispute between Burns and Commissioners; loan from Maryland; location of city, of site of public buildings; Burns's property, Carroll's property;

distinction of Carroll's house; subscription to lots, plat, and engraving of same; L'Enfant's conduct and resignation; conveyances; Hamburg, Carrollsburg, and Georgetown; appointment and duties of superintendent; private loan and property.

Package No. 14.—April 3, 1791, to December 16, 1798. Eighty-one letters. Letters from Washington, Adams, and Jefferson to the Commissioners of the Federal District, to Daniel Carroll, Gustavus Scott, Alexander White, David Stuart, William Thornton, Thomas Johnson, etc., in re location of site, platting, sale of lots, location and erection of public buildings, streets, District treasury, and money and loans, appointment and duties of superintendent, and later in re Washington's own property.

Package No. 15.—October 19, 1802, to May 2, 1808. One hundred and five letters to the President from B. H. Latrobe, surveyor (two of them from Nicholas King, assistant surveyor, one in re determining meridian of Washington).

Package No. 16.—June 16, 1802, to May 1, 1808. Sixty-five letters from Jefferson to Latrobe, Lenthall, Lenox, Monroe, in re plans of progress of Capitol, Executive Mansion, Treasury, payment of loan, excavation, funds, President's barn, Lenthall's salary and intemperance, appointment of surveyor, appropriations, donation of public land for theater, employment and salary of Latrobe, sales of lots, wages of laborers, riotous laborers, claim of Samuel Davidson, L'Enfant's salary.

EXECUTIVE OFFICE,
COMMISSIONERS OF THE DISTRICT OF COLUMBIA,
Washington, February 20, 1900.

DEAR SIR: The Commissioners have received and will give immediate attention to your letter of the 19th instant, asking for a statement from the surveyor of the District of Columbia showing the nature of papers and documents now in his custody, and which originally formed a part of the early history of Washington, together with the authority under which such papers are held.

Very respectfully, JOHN B. WIGHT,
President Board of Commissioners District of Columbia.

Hon. JAMES MCMILLAN,
Chairman Committee on the District of Columbia, United States Senate.

EXECUTIVE OFFICE,
COMMISSIONERS OF THE DISTRICT OF COLUMBIA,
Washington, March 5, 1900.

SENATOR: In further reply to your letter of February 19, requesting a statement from the surveyor of the District showing the nature of the papers and documents now in his custody, together with the authority under which such papers are held, I have to send you herewith a list of the records in the office of the surveyor relating to the early history of Washington, as requested, and also a copy of the Annual Report of the Engineer Department of the District, upon pages 140 to 143 of which will be found a compilation of the laws which it is believed place these records in the custody of the surveyor.

Very respectfully, JOHN B. WIGHT,
President Board of Commissioners District of Columbia.

Hon. JAMES MCMILLAN,
Chairman Committee on the District of Columbia, Senate.

List of records in office of the surveyor of the District of Columbia relating to the early history of the city of Washington under the administration of the first Commissioners of the city and their successors, as called for by Senator McMillan February 19, 1900.

Four books, "Records of Squares." Copies of original records showing division and allotment between the United States Commissioners and the original proprietors.

Twenty original sheets of Records of Squares, as copied in the books referred to above. K-24.

Two subdivision books, "N. K." and "B." containing subdivisions of original lots in different squares, and extending over a period from 1809 to 1860.

One book of "Reservations," containing division of the low grounds into lots in squares A, B, C, and D and in reservations 10, 11, and 12.

Four books of proceedings of the commissioners of low grounds, under act of Congress. (Stat. L., vol. 3, p. 691.)

Original deeds to lots in the low grounds.

One book of "Surveyor's Returns" of squares.

One book of "Register of Squares."

Four books of correspondence of original commissioners, being copies of the original letters, made by order of the surveyor between 1871 and 1874.

One book of "Nicholas King's Grades."

One book of "Coyle's Grades," being copies made from the original sheets by an employee of the surveyor's office.

Ellicott's map of the outlines of the District of Columbia.

Map of levels in 6 sections, marked "N. King, surveyor, 1797."

APPENDIX B.

LIST OF TREES AND SHRUBS IN THE PUBLIC GROUNDS, WASHINGTON, D. C.

[Compiled by Mr. George H. Brown, landscape gardener.]

Catalogue of native and foreign deciduous and evergreen trees and shrubs, with brief descriptions of their character and locations in the parks and park places of Washington under the supervision of the officer in charge of public buildings and grounds.

TRIANGLE AT THE INTERSECTION OF PENNSYLVANIA AVENUE AND M STREET NW.

Common name.	Botanical name.	Brief description.
Pyramidal oak	Quercus robur fastigiata	Tree of upright growth like the Lombardy poplar.
Althea, or Rose of Sharon	Hibiscus syriacus	A strong erect-growing flowering shrub.
American elm	Ulmus americana	A tree of large size and vigorous growth, regarded as among the best of our American shade trees.
American nettle tree	Celtis occidentalis	A tree of large size, with foliage resembling the American elm.

WASHINGTON CIRCLE.

American elm	Ulmus americana	Previously described.
White maple	Acer dasycarpum	A rapid-growing tree, used extensively in street plantings.
Purple-leaved maple	Acer pseudo platanus purpurea.	Ornamental medium-sized tree, desirable for park plantings. The under sides of the leaves are a deep purple color.
Japan maple	Acer polymorphum	A low-growing, very ornamental-foliaged tree.
English field maple	Acer campestre	A medium-sized symmetrical tree.
Sycamore maple	Acer pseudo platanus	Medium-sized spreading-branched tree; red-stemmed seed.
Horse chestnut	Æsculus hippocastanum	Medium-sized, handsome-foliaged flowering tree.
White poplar	Populus alba	A large, rapid-growing, hardy tree used for street plantings.
American linden	Tilia americana	A vigorous-growing, large-sized, very desirable shade tree.
European linden	Tilia europea	Medium-sized, very ornamental tree.
White birch	Betula alba	Spray-branched, white-barked ornamental tree.
White ash	Fraxinus americana	A round-headed, large, vigorous-growing tree.
European hornbeam	Carpinus betulus	A low-growing, dense-foliaged park tree.
Fern-leaved beech	Fagus heterophylla	A very graceful, slender-branched, low-growing park tree.
Purple-leaved beech	Fagus purpurea	A highly ornamental, purple-foliaged tree.
Cornelian cherry	Cornus masculus	A small ornamental flowering tree.
Japan sophora	Sophora japonica	A medium-sized, light-colored-foliaged tree from Japan.
Japan Judas tree	Cercis japonica	A low-growing, early-spring flowering tree.

Catalogue of native and foreign deciduous and evergreen trees and shrubs, with brief descriptions of their character and locations in the parks and park places of Washington under the supervision of the officer in charge of public buildings and grounds—Continued.

WASHINGTON CIRCLE—Continued.

Common name.	Botanical name.	Brief description.
Purple-leaved plum	Prunus pissardii	One of the finest purple-leaved small park trees in cultivation.
Purple Japan magnolia	Magnolia purpurea	A spreading-branched, flowering, shrubby tree.
Mist tree or purple fringe	Rhus cotinus	A low-growing tree, covered with small purple seed vessels which look in the distance like mist.
Purple-leaved hazel	Corylus avellana atropurpurea.	A spreading-branched, purple-leaved shrub.
Indian catalpa	Catalpa umbraculifera	A low-growing, picturesque tree.
Four-winged snowdrop	Halesia tetraptera	A low-growing, ornamental, flowering tree.
Bladder senna shrub	Colutea arborescens	A compact-growing, ornamental-foliaged shrub.
Althea, or Rose of Sharon	Hibiscus syriacus	Previously described.
Holly-leaved ashberry	Mahonia aquifolium	An ornamental shrub with bright, glossy foliage.
Golden chain tree	Cytisus laburnum	A low-growing, ornamental, flowering tree.
Slender-branched Deutzia	Deutzia gracilis	A dwarf white-flowering shrub.
Double-flowering Deutzia	Deutzia flora plena alba	An ornamental white-flowering shrub.
Rough-leaved Deutzia	Deutzia scabra	Do.
Mock orange, or Syringo	Philadelphus coronarius	An ornamental flowering shrub.
European privet	Ligustrum vulgare	A close-growing persistent-leaved hardy shrub, suitable for hedges.
Large-flowered exochordia	Exochordia grandiflora	A profuse-flowering very desirable ornamental shrub.
Indian currant	Symphoricarpus purpureus.	A low-growing shrub with clusters of red or purple berries.
Double-flowering meadow sweet.	Spirea reevesii flora plena	A very free-flowering desirable ornamental shrub.
Red osier dogwood	Cornus stolonifera	A bushy low-growing red-stemmed dogwood.
Purple lilac	Syringa vulgaris	A well-known free-growing free-flowering shrub.
Lavallees diervilla	Weigela lavallee	A showy dark-red flowering shrub.
Variegated-leaved diervilla	Weigela amabilis variegata.	A free-flowering shrub with variegated foliage.
Large panicle-flowered hydrangea.	Hydrangea paniculata grandiflora.	A very showy large panicle-flowered shrub.
Oak-leaved hydrangea	Hydrangea quercifolia	An ornamental-leaved flowering shrub.
Naked jasmine	Jasminum nudiflorum	One of the earliest-blooming low-growing hardy shrubs.
Adam's needle	Yucca filamentosa	Hardy herbaceous shrub, useful for planting walk intersections and bordering shrub plantings.
Norway spruce fir	Abies excelsa	A free-growing large-sized pyramidal evergreen tree.
White spruce fir	Abies alba	A light-foliaged large-sized evergreen tree.
Hemlock spruce fir	Abies canadensis	A spray-like drooping-foliaged large-sized evergreen tree.
Golden yew	Taxus baccata aurea	A low-spreading evergreen with golden foliage.
Siberian arbor vitæ	Thuja warreana	One of the hardiest of the evergreen small trees.
Tree box	Buxus sempervirens	A dark-green-leaved symmetrical evergreen shrub.

LAFAYETTE PARK.

Sugar maple	Acer saccharinum	Tree of large size, vigorous growth; desirable for park plantings and as a shade tree.
White maple	Acer dasycarpum	Previously described.
English field maple	Acer campestre	Do.
Scarlet maple	Acer rubrum	Tree of medium size, slow-growth; foliage assumes rich red color in the late autumn months.
Norway maple	Acer platanoides	Tree of large size, vigorous growth; one of the best shade trees for street plantings.
Ash-leaved maple	Acer negundo	Tree of medium size, rapid growth, and ornamental character for park plantings; not desirable for street plantings.
British oak	Quercus robur pedunculata.	Tree of large size, slow growth, wide-spreading branches.

Catalogue of native and foreign deciduous and evergreen trees and shrubs, with brief descriptions of their character and locations in the parks and park places of Washington under the supervision of the officer in charge of public buildings and grounds—Continued.

LAFAYETTE PARK—Continued.

Common name.	Botanical name.	Brief description.
White ash	Fraxinus americana	Previously described.
Spanish chestnut	Castanea vesca	Tree of large size and ornamental character, bearing larger fruit than the American chestnut tree.
Purple beech	Fagus purpurea	Previously described.
Indian bean tree	Catalpa bignonioides	Medium-sized tree, rapid growth, ornamental in foliage and flowers; desirable for park plantings only.
Southern cypress	Taxodium distichum	Tree of large size, pyramidal growth, light-green foliage; a handsome park tree.
European hornbeam	Carpinus betulus	Previously described.
Horse-chestnut	Æsculus hippocastanum	Do.
American elm	Ulmus americana	Do.
American linden	Tilia americana	Do.
Fern-leaved beech	Fagus heterophylla	Do.
Empress tree	Paulownia imperialis	Japanese tree of large size, rapid growth, panicle flowered; very ornamental in flowers and foliage.
White poplar	Populus alba	Previously described.
European beech	Fagus sylvatica	Ornamental tree, compact form, and attractive character for park plantings.
European larch	Larix europea	Pyramidal tree of large size, rapid growth, handsome light-green foliage.
Camperdown elm	Ulmus montana pendula camperdownii.	Picturesque low-growing weeping tree; one of the best of the weeping elms.
Purple Japan magnolia	Magnolia purpurea	Previously described.
Soulange's hybrid Chinese magnolia.	Magnolia soulangeana	Medium-sized profuse-blooming shrubby tree, a hybrid of M. conspicua and purpurea.
White fringe tree	Chionanthus Virginiea	A choice ornamental white-flowered low-growing shrubby tree, desirable for lawn plantings.
White-flowering dogwood	Cornus florida	Low-growing ornamental tree, profusely covered with white flowers in the early spring months.
Norway spruce fir	Abies excelsa	One of the most popular pyramidal evergreen trees, equally desirable for lawn planting as single specimens or in groups for shelter.
Bhotan pine	Pinus excelsa	A tall-growing evergreen tree with drooping silvery foliage; very ornamental.
White pine	Pinus strobus	One of the most desirable large evergreen trees for park plantings, glaucous light-green foliage.
Japan cedar	Cryptomeria japonica	A very ornamental evergreen pyramidal tree, hardy in Washington, represented to attain a height of 100 feet in Japan.
Cedar of Lebanon	Cedrus libani	A very ornamental evergreen tree, with drooping spreading branches, hardy in Washington and south of Washington.
Large-flowered magnolia	Magnolia grandiflora	A handsome-foliaged evergreen tree, bearing large sweet-scented white flowers in June and July; hardy in Washington and south of Washington.
English yew	Taxus baccata	A densely branched low-growing ornamental evergreen tree.
Irish yew	Taxus baccata fastigiata	A peculiar erect slow-growing small dark-foliaged evergreen tree, branches closely compressed; very ornamental.
Golden yew	Taxus baccata aurea	A small ornamental evergreen tree, densely branched; the young growth in the summer months assumes a rich golden color.
Colorado blue spruce fir	Abies pungens	The most ornamental of the spruce firs; foliage a rich grayish-blue color; very conspicuous tree on a lawn.
Nordmann's silver fir	Abies nordmanniana	A very ornamental, pyramidal, evergreen tree; one of the best of the silver firs for planting as a single specimen on lawns.
Oriental spruce fir	Abies orientalis	A handsome compact-branched dark-green-foliaged evergreen pyramidal tree; very desirable for lawn plantings.
Red cedar	Juniperus virginiana	Well-known American cedar, an evergreen tree with compact foliage; not usually regarded with favor for ornamental plantings.

Catalogue of native and foreign deciduous and evergreen trees and shrubs, with brief descriptions of their character and locations in the parks and park places of Washington under the supervision of the officer in charge of public buildings and grounds—Continued.

LAFAYETTE PARK—Continued.

Common name.	Botanical name.	Brief description.
American arbor vitæ	Thuja occidentalis	A native evergreen tree of small size, regarded by many as desirable for ornamental hedge plantings.
American holly	Ilex opaca	A medium-sized evergreen tree, with thick shining leaves and clusters of red berries which remain on the branches during the winter months.
European holly	Ilex aquifolium	A low-growing thickly branched evergreen tree, with larger and more ornamental foliage than the American holly; hardy in Washington and south of Washington.
Thunberg's spirea	Spirea thunbergii	A very desirable ornamental-foliaged flowering shrub introduced from Japan.
Lavellee's diervilla	Weigela lavallee	Previously described.
European privet	Ligustrum vulgare	Do.
Tartarian honeysuckle	Lonicera tatarica	An ornamental pink-flowering hardy shrub.
Indian currant	Symphoricarpus purpurea	Previously described.
Japan quince	Cydonia japonica	An ornamental red-flowering hardy shrub.
Double-flowering meadow sweet.	Spirea reevesii	Previously described.
Rose of Sharon	Hibiscus syriacus	Do.
Golden bell	Forsythia viridissima	An ornamental early-spring flowering shrub.
Japanese akebia	Akebia quinata	A hardy Japanese climbing plant with ornamental foliage and purple flowers.
Chinese wistaria	Wistaria sinensis	A hardy, rapid-growing, climbing plant having long pendulous clusters of pale, blue flowers in the early summer months.

TRIANGULAR RESERVATIONS ON PENNSYLVANIA AVENUE BETWEEN EIGHTEENTH AND TWENTY-SIXTH STREETS NW.

Indian bean	Catalpa bignonioides	Previously described.
White maple	Acer dasycarpum	Do.
Japanese pagoda tree	Sophora japonica	A handsome-foliaged and flowering medium-sized tree.
Gingo tree	Salisburia adiantifolia	A peculiar-foliaged medium-sized tree, combining in its habit characteristics of the conifers.
Camperdown elm	Ulmus montana pendula camperdownii.	Previously described.
Double-flowering meadow sweet.	Spirea reevesii	Do.
Japan quince	Cydonia japonica	Do.
Rough-leaved deutzia	Deutzia scabra	Do.
Soulange's hybrid Chinese magnolia.	Magnolia soulangeana	Do.
Purple lilac	Syringa vulgaris	Do.
Golden bell	Forsythia viridissima	Do.
English field maple	Acer campestre	Do.
Bladder senna	Colutea arborescens	Do.
Adam's needle	Yucca filamentosa	Do.
American elm	Ulmus americana	Do.
Horse-chestnut	Æsculus hippocastanum	Do.
Large-flowered magnolia	Magnolia grandiflora	Do.
Buist's variegated althea	Hibiscus variegata flore-plena Buistii.	A low-growing compactly branched variegated-foliaged shrub.
Thunberg's Japan berberry	Berberis thunbergii	Previously described.
European privet	Ligustrum vulgare	Do.
White fringe tree	Chionanthus virginica	Do.
Lovely dervilla	Weigela amabilis	A pretty profuse-blooming pink-flowered shrub.
Double-flowered plum-leaved spirea.	Spirea prunifolia flore-plena.	A vigorous-growing white-flowered shrub. The small round leaves assume various tints of color in the late autumn months.
Double-flowering apple	Malus communis alba-plena.	A medium-sized tree, with abundant showy white flowers in the early summer months.
Cornelian cherry	Cornus mascula	Previously described.
Missouri flowering currant	Ribes aureum	An early yellow-flowering shrub, shining glabrous leaves.
Nordmann's silver fir	Abies nordmanniana	Previously described.

Catalogue of native and foreign deciduous and evergreen trees and shrubs, with brief descriptions of their character and locations in the parks and park places of Washington under the supervision of the officer in charge of public buildings and grounds—Continued.

DUPONT CIRCLE.

Common name.	Botanical name.	Brief description.
Schwedler's Norway maple	Acer platanoides Schwedlerii.	A handsome-formed tree with foliage resembling the common Norway maple. The young shoots and leaves have a bright purple color in the early summer months, changing later to a dark-green color.
American elm	Ulmus americana	Previously described.
Purple-leaved beech	Fagus purpurea	Do.
European hornbeam	Carpinus betulus	Do.
Sweet gum tree	Liquidambar styraciflua	An ornamental vigorous-growing native tree; leaves star shaped, bright green in summer and turning to a purplish-crimson color in the late autumn months.
Bird cherry	Prunus padus	An ornamental medium-sized tree, blooming in May; the white flowers succeeded by clusters of small black fruit.
Siberian pea tree	Caragana arborescens	An ornamental foliaged shrubby tree with bright yellow flowers blooming in May and June.
European hornbeam	Carpinus betulus	Previously described.
Kentucky coffee tree	Gymnocladus canadensis	A large-sized tree with ornamental foliage of a bluish-green color.
Camperdown elm	Ulmus montana pendula camperdownii.	Previously described.
European beech	Fagus sylvatica	Do.
Ash-leaved maple	Acer negundo	A native tree with ash-like foliage, spreading habit; not desirable for plantings, as it is usually the first tree infested by caterpillars.
Oriental plane tree	Platanus orientalis	A rapid-growing large-sized tree; much in favor for avenue and street plantings.
Cornelian cherry	Cornus mascula	Previously described.
Golden chain tree	Cytisus laburnum	Do.
Japanese catalpa	Catalpa Kæmpferii	A rapid-growing medium-sized ornamental tree; flowers not so large as our native Catalpa; seed pods long and very narrow.
Silver-leaved linden	Tilia argentea	A large-sized very ornamental tree; leaves silvery on the under side.
European linden	Tilia europea	Previously described.
Sycamore maple	Acer pseudo platanus	Do.
Fern-leaved beech	Fagus heterophylla	Do.
Cucumber tree	Magnolia acuminata	A pyramidal medium-sized tree of rapid growth; flowers less conspicuous than the Chinese magnolias.
Chinese Koelreuteria	Koelreuteria paniculata	A medium-sized ornamental foliaged and flowering tree; very desirable for park plantings.
European white birch	Betula alba	Previously described.
Wier's cut-leaved maple	Acer dasycarpum wierii lacineatum.	An ornamental tree with graceful drooping branches; dissected foliage silvery on the under side of the leaves.
Purple-flowered magnolia	Magnolia purpurea	Previously described.
White fringe tree	Chionanthus virginica	Do.
Weeping dogwood	Cornus florida pendula	A very ornamental weeping tree; bears large white flowers, succeeded by clusters of red berries.
Japanese angelica tree	Aralia japonica	An ornamental shrubby tree with large tripennate leaves and spiny stems, flowers white, in large spikes, in the autumn months.
Double-white flowering apple.	Malus communis alba plena.	Previously described.
Paul's double-scarlet thorn	Cratægus coccinea flore pleno.	A dense branched low-growing flowering tree; slow growth; one of the best of the flowering thorns.
Chinese weeping deciduous cypress.	Glyptostrobus sinensis pendula.	A very ornamental tree of erect conical habit; foliage light green; young growth of a decidedly pendulous character.
Hemlock spruce fir	Abies canadensis	Previously described.
Rose box	Cotoneaster rotundifolia	A low-growing shrub, bearing white flowers in the spring months.
Japanese meadow sweet	Spirea Thunbergii	Previously described.
Plum-leaved meadow sweet	Spirea prunifolia	Do.
Reeve's double flowering meadow sweet.	Spirea Reevesii flore pleno	Do.
Japan snowball	Viburnum plicatum	One of the most desirable flowering shrubs, bearing balls of white flowers in profusion in May and June.

Catalogue of native and foreign deciduous and evergreen trees and shrubs, with brief descriptions of their character and locations in the parks and park places of Washington under the supervision of the officer in charge of public buildings and grounds—Continued.

DUPONT CIRCLE—Continued.

Common name.	Botanical name.	Brief description.
Guelder rose	Viburnum opulus	A vigorous-growing shrub bearing balls of white flowers resembling the Japanese snowball.
Japan barberry	Berberis hakodate	An upright-growing bush with pretty foliage and neat habit.
TRIANGLE AT THE INTERSECTION OF CONNECTICUT AVENUE AND Q STREET NW.		
Umbrella tree	Magnolia tipelala	A vigorous-growing medium-sized tree with large leaves and large cup-shaped white flowers.
Purple-flowered magnolia	Magnolia purpurea	Previously described.
Guelder rose	Viburnum opulus	Do.
Japan snowball	Viburnum plicatum	Do.
Cornelian cherry	Cornus masculus	Do.
Rose of Sharon	Hibiscus syriacus	Do.
Rose flowered dierilla	Weigela rosea	Erect compact-growing ornamental flowering shrub.
European barberry	Berberis vulgaris	An ornamental shrub bearing yellow flowers in terminal drooping racemes in May and June.
Large-flowered exochorda	Exochorda grandiflora	A vigorous-growing ornamental flowering shrub with light-colored foliage and wood; bears in profusion pure white flowers in the early spring months.
Japanese weeping cherry	Cerasus japonica rosea pendula.	A very ornamental weeping tree, the pendulous branches reaching to the ground; flowers rose colored.
African tamarisk	Tamarix africana	An ornamental slender-branched shrub with feathery foliage and pink flowers.
Norway spruce fir	Abies excelsa	Previously described.
TRIANGLES ON NEW HAMPSHIRE AVENUE BETWEEN S AND T STREETS NW.		
Buists variegated althea	Hibiscus syriacus fol. var. Buistii.	Previously described.
Naked jasmine	Jasminum nudiflorum	Do.
White oak	Quercus alba	Do.
Golden bell	Forsythia viridissima	Do.
Large-flowered exochorda	Exochorda grandiflora	Do.
Japenese snowball	Viburnum plicatum	Do.
Adams needle	Yucca filamentosa	Do.
Japanese barberry	Berberis Thunbergii	Do.
Golden-leaved meadow sweet.	Spirea opulifolia aurea	A strong-growing ornamental flowering shrub with showy distinctly yellow foliage in the spring and early summer months.
Tree box	Buxus sempervirens	Previously described.
Russian weeping mulberry	Morus tartarica pendula	One of the best small weeping trees. Forms a perfect umbrella-shaped head with pendulous branches reaching to the ground.
California privet	Lingustrum ovalifolium	A strong-growing ornamental foliaged shrub, bearing creamy-white flowers in June. An excellent ornamental hedge shrub.
Japanese double-flowering deutzia.	Deutzia crenata flora plena alba.	An ornamental flowering shrub bearing racemes of white flowers tinged with pink. Regarded as one among the most desirable flowering shrubs in cultivation.
Purple-leaved plum	Prunus pissardii	Previously described.
TRIANGLE AT THE INTERSECTION OF NEW HAMPSHIRE AVENUE AND M STREET NW.		
Red osier dogwood	Cornus stolonifera	Previously described.
Russian weeping mulberry	Morus tartarica pendula	Do.
Japanese Judas tree	Cercis japonica	Do.
Japanese sophora	Sophora japonica	Do.
Japan barberry	Berberis Thunbergii	Do.
Buists variegated althea	Hibiscus syriacus fol. var. Buistii.	Do.
Adams needle	Yucca filamentosa	Do.

Catalogue of native and foreign deciduous and evergreen trees and shrubs, with brief descriptions of their character and locations in the parks and park places of Washington under the supervision of the officer in charge of public buildings and grounds—Continued.

TRIANGLES ON VIRGINIA AVENUE BETWEEN TWENTY-SECOND AND TWENTY-FOURTH STREETS NW.

Common name.	Botanical name.	Brief description.
Indian catalpa	Catalpa umbraculifera	Previously described.
Cottonwood	Populus caroliniana	A vigorous rapid-growing tree; formerly much planted as a shade tree for streets and avenues, but now out of favor from the early shedding of its foliage.
European linden	Tilia europea	Previously described.
Purple-flowered magnolia	Magnolia purpurea	Do.
Chinese sumac	Rhus osbeckii	An ornamental small tree; the leaves in the autumn are highly colored with reddish-brown and orange tints.
Californian privet	Ligustrum ovalifolium	Previously described.
Rough-leaved deutzia	Deutzia scabra	Do.
Reeves double-flowering meadow sweet.	Spirea Reevesii	Do.
Japan snowball	Viburnum plicatum	Do.
Adams needle	Yucca filamentosa	Do.
Guelder rose	Viburnum opulus	Do.
Indian currant	Symphoricarpus purpureus.	Do.
Indian crape myrtle	Lagerstræmia indica	A very ornamental shrub, bearing in profusion showy pink flowers in the summer months; hardy in Washington and south of Washington.
Rough-leaved deutzia	Deutzia scabra	Previously described.
Japanese barberry	Berberis Thunbergii	Do.

RAWLINGS PARK.

European linden	Tilia europea	Previously described.
American linden	Tilia americana	Do.
Horse chestnut	Aesculus hippocastanea	Do.
Cucumber tree	Magnolia acuminata	Do.
Purple-flowered magnolia	Magnolia purpurea	Do.
Ash-leaved maple	Acer negundo	Do.
Japanese sophora	Sophora japonica	Do.
White birch	Betula alba	Do.
Sugar maple	Acer saccharinum	Do.
Chinese sumac	Rhus osbeckii	Do.
English field maple	Acer campestre	Do.
Silver-leaved linden	Tilia argentea	Do.
Chinese kœlreuteria	Kœlreuteria paniculata	Do.
Gingko tree	Salisburia adiantifolia	Do.
Nordmann's silver fir	Abies nordmannii	Do.
Hemlock spruce fir	Abies canadensis	Do.
Norway spruce fir	Abies excelsa	Do.
European barberry	Berberis vulgaris	Do.
American red cedar	Juniperus virginianus	Do.
Rough-leaved deutzia	Deutzia scabra	Do,
Japan quince	Cydonia japonica	Do.
Golden bell	Forsythia viridissima	Do.
Purple lilac	Syringo vulgaris	Do.
Mock orange	Philadelphus coronarius	Do.
Alder-leaved clethra	Clethra alnifolia	A native ornamental shrub with glossy leaves and bearing numerous small spikes of white fragrant flowers in the summer months.
Adam's needle	Yucca filamentosa	Previously described.
Lovely diervilla	Weigela amabilis	Do.
Bladder senna	Colutea arborescens	Do.
Oak-leaved hydrangea	Hydrangea quercifolia	Do.

M'PHERSON PARK.

Japanese acacia	Acacia nemu	A very ornamental medium-sized, handsome-foliaged, and flowering tree, hardy in Washington and south of Washington.
White maple	Acer dasycarpum	Previously described.
Fern-leaved beech	Fagus heterophylla	Do.
Scarlet oak	Quercus coccinea	A large-sized very ornamental tree; the foliage assumes rich scarlet tints in the late autumn months.
Gingko tree	Salisburia adiantifolia	Previously described.
Tartarian maple	Acer tatarica	A low-growing ornamental tree, sometimes of shrubby growth; usually one of the first of the maples to expand its leaves in the spring.

Catalogue of native and foreign deciduous and evergreen trees and shrubs, with brief descriptions of their character and locations in the parks and park places of Washington under the supervision of the officer in charge of public buildings and grounds—Continued.

M'PHERSON PARK—Continued.

Common name.	Botanical name.	Brief description.
Chinese kœlreuteria	Kœlreuteria paniculata	Previously described.
Purple-leaved peach	Persica follis purpureis	An ornamental low-growing tree; the leaves in the spring months and the young shoots in the summer are of a dull blood-red color.
American elm	Ulmus americana	Previously described.
American linden	Tilia americana	Do.
European hornbeam	Carpinus betulus	Do.
English field maple	Acer campestre	Do.
Purple-flowered magnolia	Magnolia purpurea	Do.
Purple-leaved hazel	Corylus avellana atropurpurea.	An ornamental-foliaged shrub; leaves of a deep purple color in the spring, fading to a purplish-green color in the summer.
Tartarian honeysuckle	Lonicera tatarica	Previously described.
Rough-leaved deutzia	Deutzia scabra	Do.
Naked flowered jasmine	Jasminum nudiflorum	Do.
Adam's needle	Yucca filamentosa	Do.
Mock orange	Philadelphus coronarius	Do.
Indian crape myrtle	Lagerstrœmia indica	Do.
Wayfaring tree	Viburnum lantana	An ornamental vigorous-growing shrub; leaves silvery underneath.
Japan quince	Cydonia japonica	Previously described.
White fringe tree	Chionanthus virginica	Do.
Purple-leaved plum	Prunus pissardii	Do.
Reeves's double-flowering meadow sweet.	Spirea Reevesii	Do.
Japan maple	Acer polymorphum	The most vigorous in growth of the Japan maples; foliage light green, frequently assuming rich autumnal tints of many colors.
Purple-leaved Japan maple	Acer polymorphum atropurpureum.	A low-growing shrubby tree with very attractive foliage of a dark purple color in the early summer months.
Winged spindle tree	Euonymus alatus	An ornamental shrub, branches and stem cork-barked and winged, bearing oval scarlet berries in the autumn.
Japan barberry	Berberis Thunbergii	Previously described.
Japanese purple-flowered magnolia.	Magnolia atropurpurea	Do.
Large-flowered magnolia	Magnolia grandiflora	Do.
Camperdown elm	Ulmus montana pendula camperdownii.	Do.
Japanese aralia	Aralia pentaphylla	An ornamental-foliaged shrub, leaves light green palmate (5-lobed), the branches furnished with spines.
Golden-leaved meadow sweet.	Spirea opulifolia aurea	Previously described.
Large-flowered exochorda	Exochorda grandiflora	Do.
Japanese snowball	Viburnum plicatum	Do.
Naked flowered jasmine	Jasminum nudiflorum	Do.
Red-flowering dogwood	Cornus florida flore rubra	A very ornamental low-growing tree bearing in profusion in the early summer months showy pink flowers, the edges of the petals suffused with bright red tints.
Japan quince	Cydonia japonica	Previously described.
Rose of Sharon	Hibiscus syriacus.	Do.
Colorado blue spruce fir	Abies pungens	Do.
Nordmann's silver fir	Abies nordmannii	Do.
English yew	Taxus baccata	Do.
Golden yew	Taxus baccata aurea	Do.

WASHINGTON MONUMENT GROUNDS.

Schwedler's Norway maple	Acer platanoides schwedlerii.	Previously described.
Scarlet maple	Acer rubrum	Do.
Sugar maple	Acer saccharinum	Do.
White maple	Acer dasycarpum	Do.
Ash-leaved maple	Acer negundo	Do.
Japan maple	Acer polymorphum	Do.
Horse-chestnut	Æsculus hippocastanum	Do.
Cut-leaved white birch	Betula alba laciniata	Regarded as the most ornamental among the birches; tree of large size, vigorous growth, graceful slender drooping branches and finely cut leaves, bark silvery white.

Catalogue of native and foreign deciduous and evergreen trees and shrubs, with brief descriptions of their character and locations in the parks and park places of Washington under the supervision of the officer in charge of public buildings and grounds—Continued.

WASHINGTON MONUMENT GROUNDS—Continued.

Common name.	Botanical name.	Brief description.
American nettle tree	Celtis occidentalis	Previously described.
American white ash	Fraxinus americana	Do.
European ash	Fraxinus excelsa	Do.
Kentucky coffee tree	Gymnocladus canadensis	Do.
Chinese kœlreuteria	Kœlreuteria paniculata	Do.
American plane tree	Platanus occidentalis	A large-sized rapid-growing tree, known also as the buttonwood; loose bark, which peels off, leaving the trunk with patches of yellow and green.
Downing's mulberry	Morus Downingii	A rapid-growing ornamental tree, light-colored foliage, bearing fruit, which is generally regarded as superior to the white mulberry.
Weeping Russian mulberry	Morus tartarica pendula	Previously described.
Japanese sophora	Sophora japonica	Do.
Purple-leaved plum	Prunus pissardii	Do.
Purple fringe tree	Rhus cotinus	Do.
Garland-flowering apple	Malus coronaria flore pleno.	Do.
European mountain ash	Pyrus aucuparius	An ornamental medium-sized tree, usually well furnished with clusters of scarlet berries from midsummer until late in the winter months.
Indian crape myrtle	Lagerstroemia indica	Previously described.
Rose of Sharon	Hibiscus syriacus	Do.
Buist's variegated althea	Hibiscus syriacus follis var. Buistii.	Do.
Silver-leaved oleaster	Eleagnus argentea	Do.
Cornelian cherry	Cornus mascula	Do.
White-fruited red-stemmed dogwood.	Cornus alba-sanguinea	A vigorous-growing ornamental shrub, remarkable for the bright-red color of its branches in winter.
Japanese Judas tree	Cercis japonica	Previously described.
Double white flowering cherry.	Cerasus avium alba plena	An ornamental medium-sized tree, very attractive when in bloom (May). The flowers are frequently so numerous as to conceal the branches and twigs upon which they are borne.
Mandshurian angelica tree	Dimorphanthus mandshuricus.	A very ornamental-foliaged rapid-growing shrub; leaves large, much divided, and spiny.
Large-flowered exochorda	Exochorda grandiflora	Previously described.
Golden bell	Forsythia viridissima	Do.
Naked flowered jasmine	Jasminum nudiflorum	Do.
Japanese snowball	Viburnum plicatum	Do.
Guelder rose	Viburnum opulus	Do.
Golden-leaved meadow sweet.	Spirea opulifolia aurea	Do.
Standish; Chinese honeysuckle.	Lonicera standishii	One of the earliest blooming shrubs, the creamy white fragrant flowers appearing in the early spring months before the leaves.
White pine	Pinus strobus	Previously described.

TRIANGLE BETWEEN ELEVENTH AND TWELFTH STREETS AND B STREET SW.

English field maple	Acer campestre	Previously described.
Norway maple	Acer platanoides	Do.
Japan maple	Acer polymorphum	Do.
Tartarian maple	Acer tartaricum	Do.
Purple-leaved barberry	Berberis vulgaris atropurpurea.	A handsome shrub with violet-purple foliage and fruit, very effective in groups and masses.
Cut-leaved weeping birch	Betula alba laciniata	Previously described.
Cornelian cherry	Cornus mascula	Do.
American Judas tree	Judas canadensis	A low-growing, medium-sized native tree bearing in profusion, before the leaves appear in the spring, showy pink blossoms.
Large-flowered deutzia	Deutzia grandiflora	Previously described.
Rivers purple beech	Fagus sylvatica purpurea Riversii.	A very ornamental medium-sized tree with crimson-tinted foliage in the spring, changing to dark-purple tints during the summer.
Soulange's magnolia	Magnolia soulangeana	Previously described
Golden-leaved meadow sweet.	Spirea opulifolia aurea	Do.

Catalogue of native and foreign deciduous and evergreen trees and shrubs, with brief descriptions of their character and locations in the parks and park places of Washington under the supervision of the officer in charge of public buildings and grounds—Continued.

SMITHSONIAN PARK.

Common name.	Botanical name.	Brief description.
Norway spruce fir	Abies excelsa	Previously described.
Nordmann's silver fir	Abies nordmanniana	Do.
Hemlock spruce fir	Abies canadensis	Do.
White spruce fir	Abies alba	Do.
European larch	Larix europea	Do.
Cedar of Lebanon	Cedrus libani	Do.
English yew	Taxus baccata	Do.
Golden-leaved yew	Taxus baccata aurea	Do.
Irish yew	Taxus baccata fastigiata	Do.
White pine	Pinus strobus	Do.
Tree box	Buxus sempervirens	Do.
Tulip tree, or white wood	Liriodendron tulipifera	A very ornamental native tree of large size and vigorous growth, with peculiarly shaped leaves and tulip like flowers.
Sugar maple	Acer saccharinum	Previously described.
White maple	Acer dasycarpum	Do.
Norway maple	Acer platanoides	Do.
Ash-leaved maple	Acer negundo	Do.
Scarlet maple	Acer rubrum	Do.
English field maple	Acer campestre	Do.
Japan maple	Acer polymorphum	Do.
American nettle tree	Celtis occidentalis	Do.
European white birch	Betula alba	Do.
Horse chestnut	Æsculus hippocastanum	Do.
Ohio buckeye	Æsculus glabra	An ornamental flowering native tree of large size and vigorous growth resembling in foliage the common horse chestnut, but bearing, unlike the horse chestnut, smooth-fruited seed vessels.
American chestnut	Castanea americana	A vigorous-growing, large-sized native tree with broader leaves and smaller fruit than the Spanish chestnut previously described.
West Indian bean	Catalpa speciosa	A large-sized native tree bearing large, showy white flowers and having light-green heart-shaped leaves, represented to have originated in the Western States and to be hardier than the common Indian bean, which is native to the Southern States.
Chinese cedrela	Cedrela sinensis	An ornamental-foliaged tree resembling the Ailantus in foliage and general character, of vigorous growth, and bears large trusses of fragrant white flowers.
American beech	Fagus ferruginea	A native tree of large size, compact form, and attractive foliage; one of the most desirable of American trees for general plantings.
Fern-leaved beech	Fagus heterophylla	Previously described.
American white ash	Fraxinus americana	A native tree of vigorous growth, broad, round head, and soft, light-green foliage, regarded as among the shade trees desirable for street plantings.
European ash	Fraxinus excelsior	Previously described.
Kentucky coffee tree	Gymnocladus canadensis	Do.
Three-spined honey locust	Gleditschia triacanthos	An ornamental-foliaged, medium-sized tree, useful for planting as a barrier on account of its abundant thorns.
Black walnut	Juglans nigra	A native tree of large size and attractive foliage: bark very dark in color and deeply furrowed; fruit much esteemed by many people.
Burr oak	Quercus macrocarpa	A large-sized native tree; branches curiously cork-barked; acorns nearly enveloped in conspicuously intricated, mossy fringed cups, leaves deeply lobed.
Willow oak	Quercus phellos	A compact, upright-growing tree of large size; branches slender and slightly pendulous: willow-shaped leaves.
British oak	Quercus robur	A medium-sized, spreading-branched tree of graceful appearance; the "Royal Oak" of England.
American elm	Ulmus americana	Previously described.
Yellow locust	Robinia pseudacacia	A medium-sized, rapid-growing tree with ornamental acacialike foliage: flowers in pendulous racemes, creamy white.
Japan sophora	Sophora japonica	Previously described.
Mist tree sumach	Rhus cotinus	Do.

Catalogue of native and foreign deciduous and evergreen trees and shrubs, with brief descriptions of their character and locations in the parks and park places of Washington under the supervision of the officer in charge of public buildings and grounds—Continued.

SMITHSONIAN PARK—Continued.

Common name.	Botanical name.	Brief description.
White mulberry	Morus alba	An ornamental, medium-sized tree with soft, light-green foliage; fruit white, tinged with pink when fully ripe.
White poplar	Populus alba	Previously described.
Empress tree	Paulownia imperialis	Do.
Bird cherry	Prunus padus	Do.
Garland-flowered apple	Malus coronaria flore pleno.	Do.
Rose of Sharon	Hibiscus syriacus	Do.
White-flowered dogwood	Cornus alba	Do.
Cornelian cherry	Cornus mascula	Do.
Japan quince	Cydonia japonica	Do.
Paul's double-flowering hawthorn.	Cratægus oxycantha flore pleno paulii.	Do.
Double white-flowering cherry.	Cerasus avium alba plena	Do.
Golden chain	Cytisus laburnum	Do.
Manchurian aralia	Dimorphanthus mandschuricus.	Do.
English holly	Ilex aquifolium	Do.
American holly	Ilex opaca	Do.
Benjamin tree	Linden benzoin	A shrubby tree; light-green foliage; flowers appear before the leaves expand; wood aromatic.
Indian crape myrtle	Lagerstrœmia indica	Previously described.
Purple-flowered magnolia	Magnolia purpurea	Do.
Large-leaved magnolia	Magnolia macrophylla	Do.
Large-flowered magnolia	Magnolia grandiflora	Do.
Golden bell	Forsythia viridissima	Do.
Weeping golden bell	Forsythia suspensa	An ornamental flowering shrub more slender in growth than the upright-growing golden bell; desirable for rock-work plantings.
Double-flowering pomegranate.	Punica granatum flore pleno.	An ornamental low-growing tree bearing bright-red showy double flowers; hardy in sheltered locations in Washington and south of Washington.
Reeve's meadow sweet	Spirea Reevesii flore pleno.	Previously described.
Billard's spirea	Spirea billardii	A very ornamental, vigorous-growing, pink-flowered shrub.
Japan snowball	Viburnum plicatum	Previously described.
Rose-colored weigela	Weigela rosea	An erect, compact-growing, ornamental, flowering shrub; beautiful rose-colored flowers.

HENRY PARK.

Pin oak	Quercus palustris	A tall-growing symmetrical tree; branches slightly pendulous; foliage finely divided; deep glossy green in color.
Swamp white oak	Quercus bicolor	A tree of large size and ornamental character; more rapid in growth than the white oak; foliage glossy dark green on the upper portion of the leaves, whitish underneath; bark light colored and scaly.
Scotch elm	Ulmus montana	A large-sized tree resembling our American elm in many respects, but of denser growth; a desirable tree in park plantings and also valuable as a shade tree for street and avenue plantings.
White maple	Acer dasycarpum	Previously described.
Ash-leaved maple	Acer negundo	Do.
Sycamore maple	Acer pseudo platanus	Previously described.
Schwedler's maple	Acer schwedlerii	Do.
English field maple	Acer campestre	Do.
Norway maple	Acer platanoides	Do.
Sugar maple	Acer saccharinum	Do.
Tartarian maple	Acer tartarica	Do.
Horse-chestnut	Aesculus hippocastanum	Do.
Cut-leaved weeping birch	Betula alba laciniata	Do.
Large-flowered Indian bean.	Catalpa speciosa	Do.
American white ash	Fraxinus americana	Do.
European ash	Fraxinus Europea	Do.
American beech	Fagus ferruginea	Do.
Three-spined honey locust	Gleditschia triacanthos	Do.
European linden	Tilia Europea	Do.
White-leaved European linden.	Tilia alba argentea	Do.

Catalogue of native and foreign deciduous and evergreen trees and shrubs, with brief descriptions of their character and locations in the parks and park places of Washington under the supervision of the officer in charge of public buildings and grounds—Continued.

HENRY PARK—Continued.

Common name.	Botanical name.	Brief description.
Camperdown elm	Ulmus montana pendula camperdownii.	Previously described.
Yellow locust	Robinia pseudacacia	Do.
Osage orange	Maclura aurantiaca	A vigorous growing, shrubby tree, branches covered with spines. Single specimens on a lawn form attractive low trees; largely used as a hedge plant in the Western States.
Japan Judas tree	Cercis japonica	Previously described.
Siberian pea tree	Carragana arborescens	Do.
Double-flowering white cherry.	Cerasus avium alba flore pleno.	Do.
Paul's double-flowering Hawthorn.	do	Do.
Garland-flowered apple	Malus coronaria flore pleno.	Do.
Mist tree sumach	Rhus cotinus	Do.
Japanese sophora	Sophora japonica	Do.
Japanese snowball	Viburnum plicatum	Do.
Bastard indigo	Amorpha fruticosa	Do.
Rose of Sharon	Hibiscus syriacus	Do.
Japan quince	Cydonia japonica	Do.
Oak-leaved hydrange	Hydrangea quercifolia	Do.
Fragrant upright honeysuckle.	Lonicera fragrantissima	An upright ornamental flowering shrub, light-green shining foliage, pink flowers
Standish's upright honeysuckle.	Lonicera standishii	Previously described.
European privet	Ligustrum vulgare	Do.
California privet	Pigustrum ovalifolium	Do.
Reevé's double-flowering meadow sweet.	Spirea Reevesii flore pleno.	Do.
Billard's spirea	Spirea billardii	Do.
Rose-flowered weigela	Weigela rosea	Do.
Nordmann's silver fir	Abies nordmanniana	Do.
Hemlock spruce fir	Abies canadensis	Do.
Norway spruce fir	Abies excelsa	Do.
Japan cedar	Cryptomeria japonica	Do.
Bhotan pine	Pinus excelsa	Do.
White pine	Pinus strobus	Do.
Golden English yew	Taxus baccata aurea	Do.
Ware's arbor vitæ	Thuja warreana	Do.

SEATON PARK.

Colchican maple	Acer colchicum rubrum	A tree of medium size, reddish-brown bark, foliage dark green on the matured branches, young growth bright red in color.
American elm	Ulmus americana	Previously described.
Norway maple	Acer platanoides	Do.
White maple	Acer dasycarpum	Do.
Ash-leaved maple	Acer negundo	Do.
English field maple	Acer campestre	Do.
Japan maple	Acer polymorphum	Do.
Sugar maple	Acer saccharinum	Do.
Sycamore maple	Acer pseudoplatanus	Do.
Horse-chestnut	Aesculus hippocastanum	Do.
White birch	Betula alba,	Do.
Indian bean	Catalpa speciosa	Do.
Kentucky coffee tree	Gymnocladus canadensis	Do.
Burr oak	Quercus macrocarpa	Do.
Swamp white oak	Quercus bicolor	Do.
Japanese sophora	Sophora japonica	Do.
European linden	Tillia europea	Do.
Silver-leaved linden	Tilia argentea	Do.
Hop tree	Ptelea trifoliata	A low-growing ornamental shrubby tree, have clustered flowers resembling hops.
American Judas tree	Cercis japonica	Previously described.
Garland-flowered apple	Malus coronaria flore pleno.	Do.
Japanese weeping cypress	Glyptostrobus sinensis	Do.
Fern-leaved beech	Fagus heterophylla	Do.
American nettle tree	Celtis occidentalis	Do.
American white ash	Fraxinus europea	Do.
European ash	do	Do.
Thornless honeysuckle	Gleditschia sinensis inermis.	A round-headed ornamental foliaged tree, thornless branches.
Chinese kolreuteria	Kolreuteria paniculata	Previously described.
British oak	Quercus robur	Do.
Pin oak	Quercus palustris	Do.

Catalogue of native and foreign deciduous and evergreen trees and shrubs, with brief descriptions of their character and locations in the parks and park places of Washington under the supervision of the officer in charge of public buildings and grounds—Continued.

SEATON PARK—Continued.

Common name.	Botanical name.	Brief description.
Red oak	Quercus rubra	A tall spreading tree of large size, foliage assumes a dull, crimson-purplish color in the late autumn.
Turkey oak	Quercus cerris	A tall symmetrical tree, foliage finely lobed, bright shining green in color, changing to brown in the early winter months.
Burr oak	Quercus macrocarpa	Previously described.
Gingko tree	Salisburia adiantifolia	Do.
White poplar	Populus alba	Do.
African tamarisk	Tamarix africana	Do.
Jujube tree	Zizyphus vulgaris	An ornamental glossy-leaved spiny-branched shrubby tree.
Hercules club	Aralia spinosa	A low-growing shrubby tree with large foliage and prickly stems and branches, large trusses of bloom in the summer months.
Purple-flowered magnolia	Magnolia purpurea	Previously described.
Red-stemmed dogwood	Cornus alba sanguinea	Do.
Common barberry	Berberis vulgaris	Do.
Purple-leaved barberry.	Berberis vulgaris atropurpurea.	Do.
Japan quince	Cydonia japonica	Do.
Large-flowered Deutzia	Deutzia grandiflora	Do.
Rose of Sharon	Hibiscus syriacus	Do.
Golden bell	Forsythia viridissima	Do.
Weeping golden bell	Forsythia suspensa	Do.
Mock orange	Philadelphos coronarius	Do.
Standish's upright honeysuckle.	Lonicera standishii	Do
Tartarian upright honeysuckle.	Lonicera tataricum	Do.
Japan snowball	Viburnum plicatum	Do.
Guelder rose	Viburnum opulus	Do.
Paul's double-flowering thorn.	Crataegus oxycantha Paulii flore pleno.	Do.
Holly-leaved mahonia	Mahonia aquifolium	Do.
Reeve's meadowsweet	Spirea Reevesii	Do.
Plum-leaved meadowsweet	Spirea prunifolia	Do.
Thunberg's Japan meadowsweet.	Spirea Thunbergii	Do.
Rose-flowered weigela	Weigela rosea	Do.
Tiger's tail spruce fir	Abies polita	A pyramidal formed ornamental evergreen tree of slow growth and dense habit, branches light yellow, leaves stiffly pointed.
Hemlock spruce fir	Abies canadensis	Previously described.
Norway spruce fir	Abies excelsa	Do.
White spruce fir	Abies alba	Do.
Colorado spruce fir	Abies pungens	Do.
Cephalonian fir	Picea cephalonica	A very ornamental large-sized pyramidal evergreen, foliage dark green above and silvery beneath; leaves stiff acute dagger-shaped, and spine pointed.
Nordmann's silver fir	Abies nordmanniana	Previously described.
Bhotan pine	Pinus excelsa	Do.
White pine	Pinus strobus	Do.
Chinese juniper	Juniperus chinensis	A medium sized very ornamental evergreen tree, foliage dense, silvery in the summer, turning to light brown during the winter.
Chinese arbor vitæ	Biota orientalis	A medium-sized pyramidal evergreen tree, compact light-green foliage.
Japan cedar	Cryptomeria japonica	Previously described.
Gregory's spruce fir	Abies excelsa Gregoriana	A dwarf very dense-foliaged evergreen of symmetrical form. pretty and attractive; one of the best of dwarf spruce firs.

GARFIELD PARK.

Colchican maple	Acer colchicum rubrum	Previously described,
Sycamore maple	Acer pseudoplatanus	Do.
White maple	Acer dasycarpum	Do.
Norway maple	Acer platanoides	Do.
English field maple	Acer campestre	Do.
Sugar maple	Acer saccharinum	Do.
Japan maple	Acer polymorphum	Do.

Catalogue of native and foreign deciduous and evergreen trees and shrubs, with brief descriptions of their character and locations in the parks and park places of Washington under the supervision of the officer in charge of public buildings and grounds—Continued.

GARFIELD PARK—Continued.

Common name.	Botanical name.	Brief description.
Tartarian maple	Acer Tartaricum	Previously described.
European nettle tree	Celtis australis	A vigorous-growing-medium sized ornamental tree. with long slender branches drooping at the extremities; leaves dark green.
American nettle tree	Celtis occidentalis	Previously described.
Horse-chestnut	Aesculus hippocastanum	Do.
Japanese acacia	Acacia nemu	Do.
White birch	Betula alba	Do.
Indian catalpa	Catalpa umbraculifera	Do.
European hornbeam	Carpinus betulus	Do.
American beech	Fagus ferruginea	Do.
European beech	Fagus sylvatica	Do.
Rivers's purple beech	Fagus sylvatica atropurpurea.	Do.
Cut-leaved beech	Fagus sylvatica laciniata	An erect, ornamental, medium-sized tree, with deeply-cut foliage.
European weeping beech	Fagus sylvatica pendula	A vigorous-growing, spreading, picturesque tree, of large size and peculiar shape. Its crooked, twisted branches, when divested of foliage in the winter months present an ungainly appearance. In the summer months when clothed with leaves it is, however, peculiarly graceful and pretty.
Kentucky coffee tree	Gymnocladus canadensis	Previously described.
Three-spined honey locust	Gleditschia triacanthos	Do.
European walnut	Juglans regia	A vigorous-growing tree, with strong spreading branches and handsome foliage. The edible nuts borne by this tree are much superior in quality to the nuts of the American walnut.
Chinese kolreuteria	Kolreuteria paniculata	Previously described.
Sweet gum	Liquidambar styraciflua	Do.
Osage orange	Maclura aurantiaca	Do.
Japanese kiaki elm	Planera acuminata	A medium-sized ornamental tree, foliage resembling the foliage of the elm, leaves borne on red stem; the young shoots are also red in the early summer months.
Empress tree	Paulownia imperialis	Previously described.
Oriental plane tree	Platanus orientalis	Do.
Swamp white oak	Quercus bicolor	Do.
British oak	Quercus robur	Do.
Golden-leaved oak	Quercus robur concordia	A medium-sized, very ornamental tree; leaves a bright-golden color in the summer months. Regarded as one of the most attractive trees in park plantings.
Bur oak	Quercus macrocarpa	Previously described.
Gingko tree	Salisburia adiantifolia	Do.
Japanese sophora	Sophora japonica	Do.
American linden	Tilia americana	Do.
European linden	Tilia europea	Do.
European silver-leaved linden.	Tilia argentea	Do.
Yellow wood	Virgilia lutea	An ornamental, round-headed tree of slow growth; foliage light green, assuming in the approach of the winter months golden tints. Showy white flowers in long pendent racemes in June.
American elm	Ulmus americana	Previously described.
Golden willow	Salix vitellina	An ornamental, medium-sized tree, conspicuous in winter on account of its yellow bark on trunk and branches.
Mist tree sumach	Rhus cotinus	Previously described.
Stag's horn sumach	Rhus typhina	A low-growing, ornamental, foliaged shrubby tree; branches and young stems densely velvety-hairy.
Cut-leaved sumach	Rhus glabra laciniata	A low-growing, shrubby tree, very ornamental, deeply incised large leaves, branches drooping; the foliage on the approach of winter assumes a deep red color.
Jujube tree	Zizyphus vulgaris	Previously described.
Purple-leaved plum	Prunus pissardii	Do.
African tamarisk	Tamarix africana	Do.
Purple-flowered magnolia	Magnolia purpurea	Do.

Catalogue of native and foreign deciduous and evergreen trees and shrubs, with brief descriptions of their character and locations in the parks and park places of Washington under the supervision of the officer in charge of public buildings and grounds—Continued.

GARFIELD PARK—Continued.

Common name.	Botanical name.	Brief description.
Yulan magnolia	Magnolia conspicua	An ornamental medium-sized tree; one of the earliest blooming Chinese magnolias, its large white flowers appearine before the leaves in May make this treg especially desirable for park plantings.
Large-flowered magnolia	Magnolia grandiflora	Previously described.
Bastard indigo magnolia	Amorpha fruiticosa	Do.
Rose of Sharon	Hibiscus syriacus	Do.
Buist's variegated althea	Hibiscus syriacus foliis variegatus flore-pleno.	Do.
Japanese barberry	Berberis Thunbergii	Do.
Common barberry	Berberis vulgaris	Do.
Purple-flowered callicarpa	Callicarpa purpurea	An ornamental free-growing shrub with pretty foliage, bearing numerous small bright purple flowers in August and September.
Purple-leaved hazel	Corylus avellana atropurpurea.	Previously described.
Virginian fringe tree	Chionanthus virginica	Do.
Japan Judas tree	Cercis japonica	Do.
Golden chain tree	Cytissus laburnum	Do.
Japan quince	Cydonia japonica	Do.
Paul's double-flowering thorn.	Cratægus oxycantha flore-pleno Paulii.	Do.
Red-stemmed dogwood	Cornus alba sanguinea	Do.
Cornelian cherry	Cornus mascula	Do.
Japanese weeping cherry	Cerasus japonica rosea pendula.	Do.
Siberian pea tree	Caragana arborescens	Do.
Slender branched deutzia	Deutzia gracilis	Do.
Double pink-flowering deutzia.	Deutzia crenata flore-pleno.	Do.
Manchurian aralia	Dimorphanthus mandschuricus.	Do.
Chinese lespedezia	Lespedezia bicolor	A pretty herbaceous shrub, with rosy purple flowers profusely covering its long pendent slender branches.
Wing-stemmed euonymus	Euonymus alatus	Previously described.
Silver-leaved oleaster	Eleagnus argentea	Do.
Large-flowered exochorda	Exochorda grandiflora	Do.
Golden bell	Forsythia viridissima	Do.
Bishop's cap tree	Halesia tetraptera	An ornamental shrubby tree bearing profusely clusters of white bell-shaped flowers in the early summer months; the four-winged seed vessels resemble a bishop's cap in form.
Two-winged silver-bell tree.	Halesia diptera	An ornamental shrubby tree with larger leaves and flowers than the Bishop's cap tree; the seed vessels are only two winged.
California privet	Ligustrum ovalifolium	Previously described.
European privet	Ligustrum vulgaris	Do.
Standish's upright honeysuckle.	Lonicera standishii	Do.
Hop tree	Ptelea trifoliata	Do.
Garland-flowered apple	Malus coronaria flore-pleno.	Do.
Purple lilac	Syringa vulgaris	Do.
Japanese meadow sweet	Spirea Thunbergii	Do.
Snowberry	Symphoricarpus racemosus.	A low-growing spreading bush with pretty foliage, its slender branches covered with pink flowers, which are succeeded in the autumn by white, waxy, round berries.
Reeves's meadow sweet	Spirea Reevesii	Previously described.
Golden-leaved meadow sweet.	Spirea opulifolia aurea	Do.
Rose-flowered weigela	Weigela rosea	Do.
Lovely weigela	Weigela amabilis	Do.
Japanese styrax tree	Styrax japonica	A very ornamental-foliaged and flowering low-growing shrubby tree, of rather slow growth; flowers white, bell shaped, borne along the branches.
Hemlock spruce fir	Abies canadensis	Previously described.
White spruce fir	Abies alba	Do.
Colorado blue spruce fir	Abies pungens	Do.
Nordmann's silver fir	Abies nordmanniana	Do.
Japanese cedar	Cryptomeria japonica	Do.
European holly	Ilex aquifolium	Do.
White pine	Pinus strobus	Do.

Catalogue of native and foreign deciduous and evergreen trees and shrubs, with brief descriptions of their character and locations in the parks and park places of Washington under the supervision of the officer in charge of public buildings and grounds—Continued.

GARFIELD PARK—Continued.

Common name.	Botanical name.	Brief descripion.
Bhotan pine	Pinus excelsa	Previously described.
Japanese scaly dwarf cypress	Retinospora squarrosa	An ornamental dwarf evergreen bushy tree with gray-green foliage; is a very attractive evergreen for park plantings.
Japanese golden-plumed dwarf cypress.	Retinospora plumosa aurea.	A very ornamental dwarf evergreen shrub, with golden-tinted foliage and branches, which retain this golden color throughout the entire year.
English yew	Taxus baccata	Previously described.
Golden-leaved English yew	Taxus baccata aurea	Do.

MARION PARK.

English field maple	Acer campestre	Previously described.
Schwedler's Norway maple	Acer platanoides schwedlerii.	Do.
Colchican maple	Acer colchicum rubrum	Do.
Sycamore maple	Acer pseudo platanus	Do.
Sweet-gum tree	Liquidamber styraciflua	Do.
European alder	Alnus glutinosa	A rapid-growing tree in moist locations; ornamental foliage; desirable for plantings along water courses.
American nettle tree	Celtis occidentalis	Previously described.
American hornbeam	Carpinus betulus	Do.
Purple-leaved beech	Fagus sylvatica purpurea	Do.
Chinese kolreuteria	Kolreuteria paniculata	Do.
British oak	Quercus robur	Do.
Pin oak	Quercus palustris	Do.
Shingle oak	Quercus imbricaria	A native, medium-sized, ornamental tree, with laurel-like foliage; oblong, glossy, dark-green leaves, which assume bright carmine tints on the approach of winter.
Mist tree sumach	Rhus cotinus	Previously described.
Hercules club	Aralia spinosa	Do.
Japan Judas tree	Cercis japonica	Do.
Virginian fringe tree	Chionanthus virginica	Do.
Large-flowered pavia	Pavia macrostachya	An ornamental, shrubby, dwarf-growing, smooth-fruited horse chestnut, bearing large spikes of bloom early in May.
White birch	Betula alba	Previously described.
Silver-leaved European linden.	Tilia argentea	Do.
Rose of Sharon	Hibiscus syriacus	Do.
Purple-leaved barberry	Berberis vulgaris atropurpurea.	Do.
Double-flowering deutzia	Deutzia crenata flore plena.	Do.
Golden bell	Forsythia viridissima	Do.
Weeping golden bell	Forsythia suspensa	Do.
Oak-leaved hydrangea	Hydrangea quercifolia	Do.
Naked-flowered jasmine	Jasminum nudiflorum	Do.
Standish's upright honeysuckle.	Lonicera standishii	Do.
California privet	Ligustrum ovalifolum	Do.
Purple-flowered magnolia	Magnolia purpurea	Do.
Golden-leaved meadow	Spirea opulifolia aurea	Do.
Reeve's double-flowering meadow sweet.	Spirea Reevesii flore plena	Do.
Plum-leaved meadow sweet.	Spirea prunifolia	Do.
Snowberry	Symphoricarpus racemosus.	Do.
Japan snowball	Virburnum plicatum	Do.
Rose-flowered diervilla	Weigela rosea	Do.
Lovely flowered diervilla	Weigela amabilis	Do.
Hemlock spruce fir	Abies Canadensis	Do.
Bhotan pine	Pinus excelsa	Do.
Golden-leaved yew	Taxus baccata aurea	Do.
Golden-plumed Japan dwarf cypress.	Retinospora plumosa aurea.	Do.
American arbor vitæ	Thuja occidentalis	Do.

Catalogue of native and foreign deciduous and evergreen trees and shrubs, with brief descriptions of their character and locations in the parks and park places of Washington under the supervision of the officer in charge of public buildings and grounds—Continued.

FOLGER PARK.

Common name.	Botanical name.	Brief description.
Sycamore maple	Acer pseudo platanus	Previously described.
English field maple	Acer campestre	Do.
Tartarian maple	Acer tartaricus	Do.
Norway maple	Acer platanoides	Do.
Japan maple	Acer polymorphum	Do.
White birch	Betula alba	Do.
American nettle tree	Celtis occidentalis	Do.
European hornbeam	Carpinus betulus	Do.
European cut-leaved beech	Fagus sylvatica laciniata	Do.
Purple-leaved beech	Fagus sylvatica atropurpurea.	Do.
Chinese kolreuteria	Kolreuteria paniculata	Do.
American elm	Ulmus americana	Do.
Japanese sophora	Sophora japonica	Do.
Japanese acacia	Acacia nemu	Do.
Japanese Judas tree	Cercis japonica	Do.
Virginian fringe tree	Chionanthus virginica	Do.
Bishops cap	Halesia tetraptera	Do.
Double-garland flowering apple.	Malus coronaria flore pleno.	Do.
Rose of Sharon	Hibiscus syriacus	Do.
Purple-flowered callicarpa	Callicarpa purpurea	Do.
Purple-leaved hazel	Corylus purpurea	Do.
Japan quince	Cydonia japonica	Do.
Double-flowering Japanese deutzia.	Deutzia crenata flore plena.	Do.
Weeping dogwood	Cornus florida pendula	A very ornamental small-sized weeping tree, with drooping pendulous branches covered in the blooming season with pretty white flowers, which are succeeded by clusters of red berries.
Camperdown weeping elm	Ulmus montana pendula camperdownii.	Previously described.
Soulange's hybrid magnolia.	Magnolia soulangeana	Do.
Purple-flowered magnolia	Magnolia purpurea	Do.
Cucumber tree	Magnolia accuminata	Do.
California privet	Ligustrum ovalifolium	Do.
Holly-leaved ashberry	Mahonia aquifolia	Do.
Golden-leaved meadow sweet.	Spirea opulifolia aurea	Do.
Billard's meadow sweet	Spirea billardii	Do.
Japan snowball	Viburnum plicatum	Do.
Guelder rose	Viburnum opules	Do.
Rose-flowered diervilla	Weigela rosea	Do.
Lovely flowered diervilla	Weigela amabilis	Do.
Naked-flowered jasmine	Jasminum nudiflorum	Do.
European holly	Ilex aquifolium	Do.
Norway spruce fir	Abies excelsa	Do.
White spruce fir	Abies alba	Do.
Tiger's tail spruce fir	Abies polita	Do.
Scaly dwarf Japan cypress	Retinospora squarrosa	Do.
Golden-leaved dwarf Japan cypress.	Retinospora plumosa aurea.	Do.

STANTON PARK.

Norway maple	Acer platanoides	Previously described.
White maple	Acer dasycarpum	Do.
English field maple	Acer campestre	Do.
Horse chestnut	Aesculus hippocastanum	Do.
Cut-leaved beech	Fagus sylvatica laciniata	Do.
Japanese sophora	Sophora japonica	Do.
Pin oak	Quercus palustris	Do.
Double-garland flowered apple.	Malus coronaria flore pleno.	Do.
Indian crape myrtle	Lagerstrœmia indica	Do.
Rose of Sharon	Hibiscus syriacus	Do.
Buist's double-flowered althea.	Hibiscus syriacus follis variegata flore plena Buistii.	Do.
Purpled-leaved barberry	Berberis vulgaris atropurpurea.	Do.
Red-stemmed dogwood	Cornus alba sanguinea	Do.
American Judas tree	Cercis canadensis	Do.
Siberian pea tree	Caragana arborescens	Do.
Large-flowered deutzia	Deutzia grandiflora	Do.
Japanese lespedezia	Lespedezia bicolor	Do.
Golden bell	Forsythia viridissima	Do.

Catalogue of native and foreign deciduous and evergreen trees and shrubs, with brief descriptions of their character and locations in the parks and park places of Washington under the supervision of the officer in charge of public buildings and grounds—Continued.

STANTON PARK—Continued.

Common name.	Botanical name.	Brief description.
Large panicle flowered hydrangea.	Hydrangea paniculata grandiflora.	Previously described.
Naked-flowered jasmine	Jasminum nudiflorum	Do.
Standish's upright honeysuckle.	Lonicera standishii	Do.
California privet	Ligustrum ovalifolium	Do.
Holly-leaved ashberry	Mahonia aquifolia	Do.
Purple-flowered lilac	Syringa vulgaris	Do.
Japan snowball	Viburnum plicatum	Do.
Guelder rose	Viburnum opules	Do.
Rose-flowered diervilla	Weigela rosea	Do.
Lovely flowered diervilla	Weigela amabilis	Do.
Sorbus-leaved meadow sweet.	Spirea sorbifolia	An ornamental-foliaged and flowering shrub, leaves like the mountain ash, and bearing long spikes of white flowers in July.
Golden-leaved meadow sweet.	Spirea opulifolia aurea	Previously described.
Reeve's double-flowering meadow sweet.	Spirea Reevesii flore pleno.	Do.
Thunberg's Japanese meadow sweet.	Spirea Thunbergii	Do.
Plum-leaved meadow sweet.	Spirea prunifolia	Do.
European holly	Ilex aquifolium	Do.
Hemlock spruce fir	Abies canadensis	Do.
Tiger's-tail spruce fir	Abies polita	Do.
Gregory's dwarf-spruce fir	Abies Gregoriana	Do.
Nordmann's silver fir	Abies nordmanniana	Do.
Golden-leaved dwarf Japan cypress.	Retinospora plumosa aurea.	Do.
Scaly dwarf Japan cypress	Retinospora squarrosa	Do.

LINCOLN PARK.

Sugar maple	Acer saccharinum	Previously described.
English field maple	Acer campestre	Do.
Red maple	Acer rubrum	Do.
Norway maple	Acer platanoides	Do.
Horse chestnut	Aesculus hippocastanea	Do.
Cut-leaved weeping beech	Fagus sylvatica pendula	Do.
American white ash	Fraxinus americana	Do.
Empress tree	Paulownia imperialis	Do.
Oriental plane tree	Platanus orientalis	Do.
Willow-leaved oak	Quercus phellos	Do.
White oak	Quercus alba	Do.
Pin oak	Quercus palustris	Do.
European linden	Tilia europea	Do.
American linden	Tilia americana	Do.
American elm	Ulmus americana	Do.
Large-flowered magnolia	Magnolia grandiflora	Do.
Guelder rose	Viburnum opulus	Do.
Rose-flowering diervilla	Weigela rosea	Do.
Lovely flowering diervilla	Weigela amabilis	Do.
White pine	Pinus strobus	Do.
American holly	Ilex opaca	Do.
American arbor vitæ	Thuja occidentalis	Do.

TRIANGLES ON PENNSYLVANIA AVENUE EAST OF THE UNITED STATES CAPITOL.

Ash-leaved maple	Acer negundo	Previously described.
North Carolina poplar	Populus caroliniana	Do.
Kentucky coffee tree	Gymnocladus canadensis	Do.
Japanese sophora	Sophora japonica	Do.
British oak	Quercus robur	Do.
Pauls double-flowering thorn.	Crataegus oxycantha flore pleno Paulii.	Do.
Golden bell	Forsythia viridissima	Do.
Weeping golden bell	Forsythia suspensa	Do.
Purple-flowered lilac	Syringa vulgaris	Do.
Mock orange	Philadelphos coronarius	Do.
Rose of Sharon	Hibiscus syriacus	Do.
Siberian pea tree	Caragana arborescens	Do.
Rose-flowered diervilla	Weigela rosea	Do.

Catalogue of native and foreign deciduous and evergreen trees and shrubs, with drief descriptions of their character and locations in the parks and park places of Washington under the supervision of the officer in charge of public buildings and grounds—Continued.

NURSERY GROUNDS.

Common name.	Botanical name.	Brief description.
Norway maple	Acer platanoides	Previously described.
Sycamore maple	Acer pseudo platanus	Do.
Striped barked maple	Acer pennsylvanicum	A medium-sized ornamental tree; foliage large, light green; bark dark green, with light-colored stripes along the stem.
English field maple	Acer campestre	Previously described.
Schwedler's Norway maple	Acer schwedlerii	Do.
Cut-leaved Japan maple	Acer polymorphum dissectum.	A very ornamental dwarf tree, with finely dissected foliage; branches slightly pendulous; slow growth.
American linden	Tilia americana	Previously described.
European silver linden	Tilia argentea	Do.
Sweet gum tree	Liquidamber styraciflua	Do.
Japanese mimosa tree	Acacia nemu	Do.
Papaw, or custard apple	Asiminia triloba	A low-growing ornamental tree, bearing bell-shaped greenish-purple flowers in May; foliage dark green.
Canoe birch	Betula papyracea	A very ornamental-foliaged tree, generally regarded as one of the best of birches for park plantings; pure white bark.
Weeping beech	Fagus sylvatica pendula	Previously described.
Fern-leaved beech	Fagus heterophylla	Do.
White oak	Quercus phellos	Do.
Post oak	Quercus obtusiloba	An ornamental round-headed spreading-branched tree of vigorous growth; grayish-green leaves, usually downy underneath.
Black oak	Quercus tinctoria	An ornamental free-growing large-sized tree, dark green glossy foliage; bark very dark in color.
Empress tree	Paulownia imperialis	Previously described.
Chinese cork tree	Phellodendron amurense	A medium-sized ornamental tree bearing greenish-white flowers, which are succeeded by brownish-black berries in the autumn; foliage assumes bright scarlet tints on the approach of winter.
Yellow wood	Virgilia lutea	Previously described.
Chinese kolreuteria	Kolreuteria paniculata	Do.
Virginia fringe tree	Chionanthus virginica	Do.
Double-garland flowering apple.	Malus coronaria flore plena.	Do.
Parkmans flowering apple	Pyrus malus Parkmannii	A very ornamental, small-sized tree bearing in profusion, in small bunches, rosy-pink flowers; foliage a bright, glossy green.
Rose of Sharon	Hibiscus syriacus	Previously described.
Buist's variegated double-flowering althea.	Hibiscus syriacus foliis variegatis flore pleno.	Do.
Kentucky coffee tree	Gymnocladus canadensis	Do.
Sorrel tree	Andromeda arborea	A small-sized ornamental tree, white-panicle flowered; foliage in the autumn assumes a brilliant crimson color.
Five-leaved angelica tree	Aralia quinquefolia	Previously described.
Groundsel tree	Baccharis halmifolia	A hardy, shrubby, small tree, grayish-green foliage, flower white.
Alder-leaved clethra	Clethra alnfolia	An ornamental shrub of dense low growth, light-green foliage, bearing numerous small spikes of fragrant white flowers in June and July.
Golden-chain tree	Cytisus laburnum	Previously described
White-flowering dogwood	Cornus florida	Do.
Red-stemmed dogwood	Cornus alba sanguinea	Do.
Panicled dogwood	Cornus paniculata	An ornamental flowering shrub; leaves light-green, pointed, gray on the underside; flowers greenish white.
Wild red-osier dogwood	Cornus stolonifera	Previously described.
Round leaved dogwood	Cornus circinata	An ornamental low-growing shrub; leaves round, downy underneath; flowers in small white racemes in June and July.
Silky dogwood	Cornus sericea	A low-growing shrub; light reddish stems; white-corymb flowered; bearing blue berries late in autumn.
Cornelian cherry	Cornus mascula	Previously described.
Variegated silver-leaved dogwood.	Cornus mascula variegata	An ornamental variegated-leaved variety of the Cornelian cherry; slow growth; regarded as one of the prettiest variegated shrubs in cultivation.
Manchurian aralia	Dimorphanthus ma[illegible]urica.	Previously described.

Catalogue of native and foreign deciduous and evergreen trees and shrubs, with brief descriptions of their character and locations in the parks and park places of Washington under the supervision of the officer in charge of public buildings and grounds—Continued.

NURSERY GROUNDS—Continued.

Common name.	Botanical name.	Brief description.
Variegated-leaved oleaster..	Eleagnus pungens variegata	A pretty, free-growing, spreading-branched shrub; foliage stiff and spiny; hardy in Washington and south of Washington.
Wing-stemmed spindle tree.	Euonymus alatus	Previously described.
Silver-leaved Japanese spindle tree.	Euonymus japonicus argentea variegata.	An ornamental evergreen shrub; foliage variegated silver and green; hardy in Washington and south of Washington.
Golden-leaved Japanese spindle tree.	Euonymus japonica aurea variegata.	An ornamental evergreen shrub; foliage variegated gold and green; hardy in Washington and south of Washington.
Stem-rooting Japanese spindle bush.	Euonymus radicano variegata.	A low-growing very pretty trailing shrub; variegated silvery and light-green foliage; can be trained as a climber on walls of buildings.
Large-flowered exochorda..	Exochorda grandiflora	Previously described.
Oak-leaved hydrangea	Hydrangea quercifolia	Do.
Virginian wych hazel	Hammamclis japonica	A low-growing shrubby tree oval hazel-like leaves, downy on their underside, curious small clusters of yellow flowers appear on the branches of this dwarf tree late in autumn.
American holly	Ilex opaca	Previously described.
Oriental nettle tree	Celtis orientalis	Do.
Large-flowered magnolia	Magnolia grandiflora	Do.
Cucumber tree	Magnolia acuminata	Do.
Large-leaved magnolia	Magnolia macrophylla	Do.
Umbrella tree	Magnolia tripetala	Do.
Purple-leaved Japan magnolia.	Magnolia purpurea	Do.
Hall's Japan magnolia	Magnolia stellata	A very ornamental, dwarf, shrubby magnolia, slow-growing, the earliest flowering of the Japanese magnolias.
Japanese sophora	Sophora japonica	Previously described.
Japanese storax tree	Styrax japonica	Do.
Indian crape myrtle	Lagerstœmia indica	Do.
Osbeck's Chinese sumac	Rhus osbeckii	Do.
Gum copal tree	Rhus copallina	Do.
Japanese Judas tree	Cercis japonica	Do.
Japan quince	Cydonia japonica	Do.
Bladder senna	Colutea arborescens	Do.
Japanese snowball	Viburnum plicatum	Do.
Guelder rose	Viburnum opulus	Do.
Mock orange	Philadelphos coronarius	Do.
Common barberry	Berberis vulgaris	Do.
Purple-leaved barberry	Berberis vulgaris atropurpurea.	Do.
Japanese barberry	Berberis thunbergii	Do.
Bladder senna	Colutea arborescens	Do.
Double-flowering Japanese deutzia.	Deutzia crenata flore plena.	Do.
Rough-leaved deutzia	Deutzia scabra	Do.
Dwarf rough-leaved deutzia.	Deutzia scabra vera	An ornamental flowering shrub, with small clusters of bell-shaped flowers; foliage very rough underneath. This variety is the true deutzia scabra, but is not superior to the variety more commonly known as deutzia scabra.
Large panicle-flowered hydrangea.	Hydrangea paniculata grandiflora.	Previously described.
Black alder	Ilex verticillata	An ornamental shrub, bearing small waxy white flowers, which are succeeded by bright red berries, which retain their color during the winter months.
California privet	Ligustrum ovalifolium	Previously described.
Japan privet	Ligustrum ibota	An ornamental shrub of spreading habit; glossy narrow leaves.
Golden-leaved mock orange.	Philadelphus aurea	A pretty golden-foliaged variety of the well-known mock orange, less vigorous in growth and of dwarfer habit than the parent variety, but very desirable for ornamental plantings.
Dwarf mock orange	Philadelphus dianthiflorus flore plena.	A dwarf variety of the mock orange with double cream-colored flowers.
Cordate-leaved mock orange.	Philadelphus cordatus	A variety of the mock orange with heart-shaped leaves.
White-leaved mock orange..	Philadelphus nivalis	A variety of the mock orange; the underneath of the leaves are grayish white.
Large-flowered mock orange.	Philadelphus grandiflora	Previously described.

Catalogue of native and foreign deciduous and evergreen trees and shrubs, with brief descriptions of their character and locations in the parks and park places of Washington under the supervision of the officer in charge of public buildings and grounds—Continued.

NURSERY GROUNDS—Continued.

Common name.	Botanical name.	Brief description.
Japanese white kerria	Rhodotypus kerrioides	An ornamental-foliaged flowering shrub, bearing numerous pure white flowers; very desirable for shrub plantings.
Sorbus-leaved meadow	Spirea sorbifolia	Previously described.
Reeve's double-flowering meadow sweet.	Spirea Reevesii flora plena.	Do.
Plum-leaved meadow sweet.	Spirea prunifolia	Do.
Golden-leaved meadow sweet.	Spirea opulifolia aurea	Do.
Japanese meadow sweet	Spirea Thunbergii	Do.
Anthony Waterer's meadow sweet.	Spirea Anthony Waterer	A very pretty dwarf pink-flowering shrub, one of the best of the dwarf Spireas; similar in habit of growth to Spirea bumalda.
Slender-branched stephanandra.	Stephanandra flexuosa	A pretty foliaged shrub, bearing small white flowers resembling in character the Meadow Sweets.
Purple lilac	Syringa vulgaris	Previously described.
Rose-flowered weigela	Weigela rosea	Do.
Sorbus-leaved xanthoceras	Xanthoceras sorbifolia	A very pretty flowered low-growing tree with foliage resembling the mountain ash; bears terminal clusters of variegated white and brown petaled flowers which are exceedingly showy and attractive.
Colorado blue spruce fir	Abies pungens	Previously described.
Nordmann's silver fir	Abies Nordmanniana	Do.
Hemlock spruce fir	Abies canadensis	Do.
Finedon spruce fir	Abies finedonensis	A peculiarly variegated variety of the spruce fir; compact habit. The foliage of the young growth tipped pale yellow, changing to bronze-green later in the season.
Norway spruce fir	Abies excelsa	Previously described.
White pine	Pinus strobus	Do.
Bhotan pine	Pinus excelsa	Do.
Mugho pine	Pinus mughus	A very dwarf spreading-branched spruce fir; very ornamental in character.
Lawson's cypress	Cupressus lawsoniana	A very ornamental foliaged cypress, the leading shoots having a graceful drooping habit. Hardy in Washington and south of Washington.
English yew	Taxus baccata	Previously described.

FRANKLIN PARK.

Common name.	Botanical name.	Brief description.
American elm	Ulmus americana	Previously described.
Scotch elm	Ulmus montana	A rapid-growing large-sized ornamental tree; leaves larger than the American elm.
English elm	Ulmus campestris	An erect, tall-growing, compactly branched, ornamental tree; leaves smaller than the American elm.
English field maple	Acer campestre	Previously described.
Sugar maple	Acer saccharinum	Do.
Norway maple	Acer platanoides	Do.
Sycamore maple	Acer pseudoplatanus	Do.
White maple	Acer dasycarpum	Do.
American linden	Tilia americana	Do.
European linden	Tilia europea	Do.
Ohio buckeye	Pavia flava	Do.
Horse chestnut	Æsculus hippocastanum	Do.
Empress tree	Paulownia imperialis	Do.
White oak	Quercus alba	Do.
Post oak	Quercus obtusiloba	Do.
Chestnut oak	Quercus prinus	A large-sized vigorous-growing tree, leaves bearing a close resemblance to the American chestnut.
Pin oak	Quercus palustris	Previously described.
European beech	Fagus sylvatica	Do.
Purple-leaved beech	Fagus sylvatica purpurea	Do.
Fern-leaved beech	Fagus heterophylla	Do.
Cucumber tree	Magnolia acuminata	Do.
Double-flowering white cherry.	Cerasus avium flora plena	Do.

Catalogue of native and foreign deciduous and evergreen trees and shrubs, with brief descriptions of their character and locations in the parks and park places of Washington under the supervision of the officer in charge of public buildings and grounds—Continued.

FRANKLIN PARK—Continued.

Common name.	Botanical name.	Brief description.
American black walnut	Juglans nigra	A large-sized vigorous-growing tree, with spreading branches and ornamental foliage, valued for its fruit.
White poplar	Populus alba	Previously described.
Cut-leaved white birch	Betula alba laciniata	Do.
Chinese kolreuteria	Kolreuteria paniculata	Do.
Indian bean	Catalpa bignonioides	Do.
Yulan magnolia	Magnolia conspicua	Do.
Purple-flowered magnolia	Magnolia purpurea	Do.
Purple lilac	Syringa vulgaris	Do.
Mock orange	Philadelphus coronarius	Do.
Golden bell	Forsythia viridissima	Do.
Japanese barberry	Berberis Thunbergii	Do.
Japanese quince	Cydonia japonica	Do.
Snow berry	Symphoricarpus racemosus	Do.
Plum-leaved viburnum	Viburnum prunifolium	A low-growing shrubby tree, glossy foliage, white flowers and dark purple berries.
Rough-leaved deutzia	Deutzia scabra	Previously described
Double-flowering apple	Malus cornaria flore plena	Do.
Cranberry tree	Viburnum oxycoccus	Do.
Guelder rose	Viburnum opulus	Do.
Japanese snowball tree	Viburnum plicatum	Do.
Japanese double-flowered deutzia.	Deutzia crenata flore plena.	Do.
Large panicle-flowered hydrangea.	Hydrangea paniculata grandiflora.	Do.
California privet	Ligustrum ovalifolium	Do.
Japanese katsura tree	Cercidiphyllum japonica	An ornamental shrubby tree, leaves heart-shaped, closely resembling the Japan Judas tree.
Reeve's double-flowering meadow sweet.	Spirea reevesii flora plena	Previously described.
White pine	Pinus strobus	Do.
Hemlock spruce fir	Abies canadensis	Do.
American arbor vitæ	Thuja occidentalis	Do.
Nordmann's silver fir	Picea nordmanniana	Do.

TRIANGULAR RESERVATIONS ON MASSACHUSETTS AND NEW YORK AVENUES NW., INCLUDING SCOTT CIRCLE, THOMAS CIRCLE, AND SHIELDS CIRCLE.

American linden	Tilia americana	Previously described.
American elm	Ulmus americana	Do.
Tulip poplar tree	Liriodendron tulipifera	Do.
Japanese sophora	Sophora japonica	Do.
Post oak	Quercus obtusiloba	Do.
Purple-leaved beech	Fagus sylvatica purpurea	Do.
American nettle tree	Celtis occidentalis	Do.
Chinese kolreuteria	Kolreuteria paniculata	Do.
Japanese ginko tree	Salisburia adiantifolia	Do.
Double-flowering apple tree.	Malus coronaria flora plena.	Do.
Paul's double-flowering thorn.	Cratægus oxycantha flora plena Paulii.	Do.
Purple-flowered magnolia	Magnolia purpurea	Do.
White-flowering dogwood	Cornus florida	Do.
Norbert's magnolia	Magnolia Norbertiana	A vigorous growing shrubby tree; foliage resembling Magnolia soulangeana; flowers in April and May; color, light-purplish pink.
Hall's Japanese magnolia	Magnolia stellata	Previously described.
Purple lilac	Syringa vulgaris	Do.
Japan quince	Cydonia japonica	Do.
Golden bell	Forsythia viridissima	Do.
Mock orange	Philadelphus coronarius	Do.
Reeve's double-flowering meadowsweet.	Spirea Reevesii flora plena.	Do.
Plum-leaved meadowsweet.	Spirea prunifolia	Do.
Thunberg's Japan meadowsweet.	Spirea Thunbergii	Do.
Golden-leaved meadowsweet	Spirea opulifolia aurea	Do.
Red-stemmed dogwood	Cornus alba sanguinea	Do.
Rose-flowered weigela	Weigela rosea	Do.
African tamarisk	Tamarix africana	Do.
American Judas tree	Cercis canadensis	Do.
Oak-leaved hydrangea	Hydrangea quercifolia	Do.
Missouri currant	Ribes aureum	Do.
Double-flowering deutzia	Deutzia crenata flore plena.	Do.

Catalogue of native and foreign deciduous and evergreen trees and shrubs, with brief descriptions of their character and locations in the parks and park places of Washington under the supervision of the officer in charge of public buildings and grounds—Continued.

TRIANGLE RESERVATIONS ON MASSACHUSETTS AND NEW YORK AVENUES NW., INCLUDING SCOTT CIRCLE, THOMAS CIRCLE, AND SHIELDS CIRCLE—Continued.

Common name.	Botanical name.	Brief description.
Purple-leaved barberry	Berberis vulgaris purpurea.	Previously described.
Virginian fringe tree	Chionanthus virginica	Do.
Rose of Sharon	Hibiscus syriacus	Do.
Guelder rose	Viburnum opulus	Do.
Japan snow ball	Viburnum plicatum	Do.
Tartarian honeysuckle	Lonicera tatarica	Do.
California privet	Ligustrum ovalifolium	Do.
Jujube tree	Zizyphus jujuba	Do.
Camperdown elm	Ulmus montana pendula camperdownensis.	Do.
Hemlock spruce fir	Abies canadensis	Do.
Golden-leaved yew	Taxus baccata aurea	Do.
Large-flowered magnolia	Magnolia grandiflora	Do.
European holly	Ilex aquifolium	Do.

TRIANGULAR RESERVATIONS, MASSACHUSETTS AVENUE NE.

Common name.	Botanical name.	Brief description.
Cork-barked elm	Ulmus suberosa	A medium-sized spreading-branched tree; branches cork-barked; foliage resembling the English elm.
American linden	Tilia americana	Previously described.
White oak	Quercus alba	Do.
Sycamore maple	Acer pseudo-platanus	Do.
Rose of Sharon	Hibiscus syriacus	Do.
Japanese snow ball	Viburnum plicatum	Do.
Norway spruce fir	Abies excelsa	Do.
White pine	Pinus strobus	Do.
Hemlock spruce fir	Abies canadensis	Do.

TRIANGLE AT THE INTERSECTION OF A AND FIRST STREETS NE.

Common name.	Botanical name.	Brief description.
Japanese sophora	Sophora japonica	Previously described.
Japanese snow ball tree	Viburnum plicatum	Do.
Purple lilac	Syringa vulgaris	Do.
African tamarisk	Tamarix africana	Do.
American Judas tree	Cercis canadensis	Do.
Double-flowering Japanese deutzia.	Deutzia crenata flora plena	Do.
Rose-flowered weigela	Weigela rosea	Do.
Golden bell	Forsythia viridissima	Do.
Weeping golden bell	Forsythia suspensa	Do.

JUDICIARY PARK.

Common name.	Botanical name.	Brief description.
Norway maple	Acer platanoides	Previously described.
Sugar maple	Acer saccharinum	Do.
White maple	Acer dasycarpum	Do.
Ash-leaved maple	Acer negundo	Do.
Sycamore maple	Acer pseudo-platanus	Do.
English field maple	Acer campestre	Do.
Japanese maple	Acer polymorphum	Do.
Colchican maple	Acer colchicum rubrum	Do.
American black ash	Fraxinus sambucifolia	A large vigorous-growing tree; foliage broader than the white ash.
Black walnut	Juglans nigra	Previously described.
Indian bean	Catalpa bignonioides	Do.
Japanese catalpa	Catalpa kæmpferii	Do.
Gingko tree	Salisburia adiantifolia	Do.
Japanese sophora	Sophora japonica	Do.
European weeping beech	Fagus sylvatica pendula	Do.
Fern-leaved beech	Fagus heterophylla	Do.
Japanese acacia	Acacia julibrissin	Do.
Empress tree	Paulownia imperialis	Do.
Chinese kolreuteria	Kolreuteria paniculata	Do.
Yellow wood	Virgilia lutea	Do.
Horse-chestnut	Æsculus hippocastanum	Do.
Kentucky coffee tree	Gymnocladus canadensis	Do.
Large-leaved magnolia	Magnolia macrophylla	Do.
Double-flowering apple	Malus coronaria flora plena.	Do.
Camperdown elm	Ulmus montana pendula camperdownensis.	Do.

Catalogue of native and foreign deciduous and evergreen trees and shrubs, with brief descriptions of their character and locations in the parks and park places of Washington under the supervision of the officer in charge of public buildings and grounds—Continued.

JUDICIARY PARK—Continued.

Common name.	Botanical name.	Brief description.
African tamarisk	Tamarix africana	Previously described,
Tartarian honeysuckle	Lonicera tatarica	Do.
Golden bell	Forsythia viridissima	Do.
Lavallee's diervilla	Weigela lavallee	Do.
Japan quince	Cydonia japonica	Do.
Guelder rose	Viburnum opulus	Do.
Rose of Sharon	Hibiscus syriacus	Do.
Reeve's double-flowering meadowsweet.	Spirea reevesii flora plena	Do. Do.
Golden-leaved meadow-sweet.	Spirea opulifolia aurea	Do. Do.
Red-stemmed dogwood	Cornus alba sanguinea	Do.
Purple-leaved hazel	Corylus purpurea	Do.
Japanese barberry	Berberis Thunbergii	Do.
Rough-leaved deutzia	Deutzia scabra	Do.
Virginian fringe tree	Chionanthus virginica	Do.
Purple-leaved plum	Prunus pissardii	Do.
American spindle tree	Euonymus americana	Do.
Wing-stemmed spindle tree.	Euonymus alatus	Do.
Snow berry	Symphoricarpus racemosus	Do.
Indian crape myrtle	Lagerstœmia indica	Do.
Naked-flowered jasmine	Jasminum nudiflorum	Do.
Japanese snow ball tree	Viburnum plicatum	Do.
Missouri currant	Ribes aureum	Do.
Japan Judas tree	Cercis japonica	Do.
Purple-flowered magnolia	Magnolia purpurea	Do.
Cornelian cherry	Cornus mascula	Do.
California privet	Ligustrum ovalifolium	Do.
Norway spruce fir	Abies excelsa	Do.
Hemlock-spruce fir	Abies canadensis	Do.
Nordmann's silver fir	Picea nordmanniana	Do.

PRESIDENT'S PARK, INCLUDING THE INCLOSED GROUNDS OF THE EXECUTIVE MANSION.

Sugar maple	Acer saccharinum	Previously described.
White maple	Acer dasycarpum	Do.
Norway maple	Acer platanoides	Do.
Sycamore maple	Acer pseudo-platanus	Do.
Scarlet maple	Acer rubrum	Do.
Tartarian maple	Acer tartarica	Do.
Circinate-leaved maple	Acer circinatum	Do.
English field maple	Acer campestre	Do.
Wier's cut-leaved maple	Acer dasycarpum weirii laciniatum.	Do.
Purple-leaved sycamore maple.	Acer pseudo-platanus follis purpureis.	Do.
Eagle's claw maple	Acer platanoides laciniatum.	A low-growing ornamental tree; foliage pointed and curled down at the points, resembling an eagle's claw.
Japan maple	Acer polymorphum	Previously described.
Blood-red-leaved Japan maple.	Acer polymorphum sanguineum.	Very ornamental dwarf trees; foliage curiously cut and variegated; very desirable for park plantings.
Cut-leaved purple Japan maple.	Acer polymorphum dissectum atropurpureum.	
Pinnate-leaved purple Japan maple.	Acer polymorphum pinnatifidum atropurpureum.	
Recticulated-leaved Japan maple.	Acer polymorphum recticulatum.	
Palmate-leaved Japan maple.	Acer polymorphum palmatum.	
Crisp-leaved Japan maple	Acer polymorphum cristatum.	
Red-margined Japan maple.	Acer polymorphum roseo marginatum.	
Spanish chestnut	Castanea vesca	Previously described.
American chestnut	Castanea americana	A large-sized ornamental tree, with wide spreading branches, producing smaller fruit than the Spanish chestnut.
European beech	Fagus sylvatica	Previously described.
American beech	Fagus ferruginea	Do.
Fern-leaved beech	Fagus heterophylla	Do.
Purple-leaved beech	Fagus purpurea	Do.
Tulip tree	Liriodendron tulipifera	Do.
Kentucky coffee tree	Gymnocladus canadensis	Do.
White birch	Betula alba	Do.

Catalogue of native and foreign deciduous and evergreen trees and shrubs, with brief descriptions of their character and locations in the parks and park places in Washington under the supervision of the officer in charge of public buildings and grounds—Continued.

PRESIDENT'S PARK, INCLUDING THE INCLOSED GROUNDS OF THE EXECUTIVE MANSION—Continued.

Common name.	Botanical name.	Brief description.
Cut-leaved white birch	Betula alba laciniata	Previously described.
Indian bean	Catalpa bignonioides	Do.
European ash	Fraxinus excelsior	Do.
American white ash	Fraxinus americana	Do.
American green ash	Fraxinus viridis	A western variety of the American ash; an ornamental-foliaged tree not as tall growing as the white ash.
Variegated-leaved ash	Fraxinus concavefolia variegata.	A medium-sized tree, with variegated foliage resembling the variegated Aucuba.
Black walnut	Juglans nigra	Previously described.
Chinese kolreuteria	Kolreuteria paniculata	Do.
Empress tree	Paulownia imperialis	Do.
American plane tree	Platanus occidentalis	Do.
European plane tree	Platanus orientalis	Do.
Swamp white oak	Quercus bicolor	Do.
Turkey oak	Quercus cerris	Do.
Laurel oak	Quercus imbricaria	Do.
Bur oak	Quercus macrocarpa	Do.
Pin oak	Quercus palustris	Do.
Chestnut oak	Quercus prinas	Do.
Willow oak	Quercus phellos	Do.
Red oak	Quercus rubra	Do.
Scarlet oak	Quercus coccinea	Do.
Hungarian oak	Quercus pannonica	A very ornamental foliaged oak; leaves large, deeply indented.
Golden-leaved oak	Quercus robur concordia	A very pretty medium-sized ornamental tree. The young foliage in the spring and early summer months is of a bright golden color, very conspicuous.
Louett's oak	Quercus robur Louetti	A vigorous-growing ornamental tree, foliage dark green; desirable in a collection of oaks.
Sessile flowered oak	Quercus sessiliflora	A subspecies of the British oak previously described; light-colored bark and pale-green foliage; acorns very shortly stalked.
Pyramidal oak	Quercus robur fastigiata	Previously described.
British oak	Quercus robur	Do.
European linden	Tilia europea	Do.
Silver-leaved European linden.	Tilia argentea	Do.
American linden	Tilia americana	Do.
Horse-chestnut	Æsculus hippocastanum	Do.
American elm	Ulmus americana	Do.
English elm	Ulmus campestris	Do.
Camperdown elm	Ulmus montana pendula camperdownensis.	Do.
White poplar	Populus alba	Do.
American nettle tree	Celtis occidentalis	Do.
Japanese sophora	Sophora japonica	Do.
European hornbeam	Carpinus betulus	Do.
Golden-branched willow	Salix vitellina	Do.
Yellow locust	Robinia pseudo acacia	Do.
European mountain ash	Sorbus aucuparia	A rapid-growing small tree, with pretty foliage and scarlet berries.
Japanese styrax	Styrax japonica	A low-growing ornamental shrubby tree, with pretty foliage and bell-shaped white flowers.
Purple-leaved plum	Prunus pissardii	Previously described.
Double-flowering cherry	Cerasus avium alba plena	Do.
Ohio buckeye	Pavia flava	Do.
Siebold's double-flowering cherry.	Cerasus Sieboldii	One of the best of the flowering cherries, bearing large red flowers tinged with rose color.
Bird cherry	Prunus padus	Previously described.
Umbrella tree	Magnolia tripetala	Do.
Soulange's magnolia	Magnolia soulangeana	Do.
Hall's Japan magnolia	Magnolia stellata	Do.
Purple magnolia	Magnolia purpurea	Do.
Mist tree sumac	Rhus cotinus	Do.
Hop tree	Ptelia trifoliata	Do.
Chinese tamarisk	Tamarix gallica	A very ornamental, slender-branched, shrubby tree, foliage resembling the African tamarisk, previously described.
Virginian fringe tree	Chionanthus virginica	Previously described.
Snowdrop tree, or bishop's cap.	Halesia tetraptera	Do.
Standish's upright honeysuckle.	Lonicera standishii	Do.

Catalogue of native and foreign deciduous and evergreen trees and shrubs, with brief descriptions of their character and locations in the parks and park places in Washington under the supervision of the officer in charge of public buildings and grounds—Continued.

PRESIDENT'S PARK, INCLUDING THE INCLOSED GROUNDS OF THE EXECUTIVE MANSION—Continued.

Common name.	Botanical name.	Brief description.
California privet	Lonicera ovalifolium	Previously described.
Bastard indigo	Amorpha fruticosa	Do.
Hercules club	Aralia spinosa	Do.
Japan barberry	Berberis Thunbergii	Do.
Purple-leaved barberry	Berberis atropurpurea	Do.
Snowberry	Symphoricarpus racemosus.	Do.
Golden bell	Forsythia viridissima	Do.
Japanese snowball	Viburnum plicatum	Do.
Rose of Sharon	Hibiscus syriacus	Do.
Japan quince	Cydonia japonica	Do.
Holly-leaved mahonia	Mahonia aquifolia	Do.
Jujube tree	Zizyphus jujuba	Do.
Guelder rose	Viburnum opulus	Do.
Silver-leaved oleaster	Eleagnus argentea	Do.
Double-flowering mock orange.	Philadelphus coronaria flora plena.	Do.
Sea buckthorn	Hippophea rhamnoides	A low-growing, ornamental tree; grayish-green foliage.
Osbeck's sumac tree	Rhus osbeckii	Previously described.
Oriental nettle tree	Celtis orientalis	Do.
Cornelian cherry	Cornus mascula	Do.
Purple-leaved hazel	Corylus purpurea	Do.
Garland-flowering apple tree	Malus coronarius	Do.
Large-flowered exochorda	Exochorda grandiflora	Do.
Japanese acacia	Acacia nemu	Do.
Indian crape myrtle	Lagerstrœmia indica	Do.
Weeping pespedezia	Lespedezia pendulifolium	Do.
Three-leaved citron	Citrus trifoliatus	A vigorous-growing low shrub, with glossy, dark-green foliage, hardy in Washington and south of Washington.
Sweet-pepper bush	Clethra alnfolia	Previously described.
Red-flowered dogwood	Cornus florida rubra	Do.
Japanese parrotia	Parrotia japonica	An ornamental small shrubby tree, its chief attraction being the rich autumnal tints of its foliage,
Missouri currant	Ribes areum	Previously described.
Lovely diervilla	Weigela amabilis	Do.
Rose-flowered weigela	Weigela rosea	Do.
Panicle-flowered hydrangea	Hydrangea paniculata grandiflora.	Do.
Reeve's double-flowering meadow sweet.	Spirea Reevesii flore pleno	Do.
Golden-leaved meadow sweet	Spirea opulifolia aurea	Do.
Plum-leaved meadow sweet.	Spirea prunifolia	Do.
Billard's meadow sweet	Spirea Billardii	Do.
Japanese meadow sweet	Spirea Thunbergii	Do.
White spruce fir	Abies alba	Do.
Norway spruce fir	Abies excelsa	Do.
Oriental spruce fir	Abies orientalis	Do.
Tiger's tail spruce fir	Abies polita	Do.
Colorado blue spruce fir	Picea pungens	Do.
Black spruce fir	Abies nigra	An ornamental pyramidal-growing evergreen tree, with drooping branches: cones dark colored
Nordmann's silver fir	Abies nordmanniana	Previously described.
Hemlock spruce fir	Abies canadensis	Do.
Cephalonian fir	Picea cephalonica	Do.
Conical spruce fir	Abies excelsa conica	A pyramidal evergreen tree of compact growth, resembling the Norway spruce fir, but of smaller sized growth.
Gregory's dwarf spruce fir	Abies Gregoriana	Previously described.
Noble silver fir	Picea nobilis	A very ornamental pyramidal evergreen tree with silvery foliage, slow in growth.
Siberian silver fir	Picea pichta	A medium-sized very ornamental tree; leaves very dark green, soft to the touch; unlike the other silver firs.
Bhotan pine	Pinus excelsa	Previously described.
Austrian pine	Pinus austriacus	A vigorous-growing evergreen tree, with dark-green foliage; much used in shelter plantings.
White pine	Pinus strobus	Previously described.
Scotch pine	Pinus sylvestris nana	A low-growing evergreen tree, with short bluish-green foliage.
Corean pine	Pinus Koraiensis	A medium-sized ornamental evergreen, with soft, dark-green, very pretty foliage.
Swiss stone pine	Pinus cembra helvetica	An erect-growing, handsome evergreen tree, with dense foliage.
English yew	Taxus baccata	Previously described.

Catalogue of native and foreign deciduous and evergreen trees and shrubs, with brief descriptions of their character and locations in the parks and park places of Washington under the supervision of the officer in charge of public buildings and grounds—Continued.

PRESIDENT'S PARK, INCLUDING THE INCLOSED GROUNDS OF THE EXECUTIVE MANSION—Continued.

Common name.	Botanical name.	Brief description.
Golden-leaved yew	Taxus baccata aurea	Previously described.
Bald cypress	Taxodium distichum	Do.
American arbor vitæ	Thuja occidentalis	Do.
Umbrella pine	Sciadopitys verticillata	A slow-growing, very ornamental dark-green foliaged evergreen tree; leaves arranged in whorls on the branches.
Chinese weeping cypress	Glyptostrobus simensis pendula.	Previously described.
Large-leaved magnolia	Magnolia grandiflora	Do.
Glaucous-leaved magnolia	Magnolia glauca	A very pretty glaucous-foliaged magnolia, with cup-shaped white fragrant flowers.
Box tree	Buxus sempervirens	Previously described.
Squarrose-leaved dwarf Japan cypress.	Retinospora squarrosa	Do.
Fern-leaved dwarf Japan cypress.	Retinospora obtusa nana	A very pretty dwarf evergreen tree with dense, deep green foliage.

List of tropical and semitropical plants, palms, ferns, flowering and bedding plants in the general collection of the propagating gardens.

Azalea Apollon.
  Deutche Perle.
  Dame Melanie.
  Empereur de Bresil.
  Empress of India.
  Madame de Greve.
  Madame Vander Cruyssen.
  Simon Mardner.
  Memoire de Louis Van Houtte.
  Vervaeneana.
Alocasia sedenii.
  Sanderiana.
  Porteana.
  metallica.
  Thibautiana.
  macrorhiza.
Amomum cardamomum.
  vittata.
Aspidistra lurida variegata.
Anthurium Andreanum.
  magnificum.
  ferrierense.
Amaryllis in variety.
Ananassa sativa variegata.
  Porteana.
Aralia filicifolia.
  guilfoylei.
  Veitchei.
  gracillimum.
Asparagus plumosa.
Ardisia crenulata rubra.
Aristolochia ornicephela.
Antigonum leptotus.
Alpinia vittata variegata.
Agave stricta.
  Victoria.
Araucaria Bidwillii.
  Cunninghami glauca.
  excelsa.
  excelsa glauca.
Aloysia citriodora.
Amorphophallus Rivieri.
Agapanthus umbellatus.
Aphelandra aurantiaca roezlii.
Acorus japonica.
Ageratum "little gem."
Alternanthera brillantissima.
  aurea nana.
  versicolor.
  spectabilis.
Acalypha Sanderiana.
  macafeana.
  godseffiana.
Abutilon souv de bonn.
  savitzii.
  marmorata.
Achyranthus brilliantissima.
  tricolor.
  sunrise.
  superba.
  Princess of Wales.
Alamanda hendersonii.
  williamsii.
Astilbe japonica.
Begonia Vernon.
  Queen of Bedders.
  manicata aurea.
  gogoensis.
  Louis Clossom.
  ducherterii.
  Glorie de Lorraine.
Bertolonia Van Houttei.
  marmorata.
Bignonia venusta.
Bryophyllum calycinum.
Bromeria argyrea.
Bletia Tankervilla.
  sheperdii.
Bouvardia leantha.
  Davidsoni.
Caladium esculentum.
Cactus in variety.
Campyllobotris refulgens.
Cobea scandens.

List of tropical and semitropical plants, palms, ferns, flowering and bedding plants in the general collection of the propagating gardens—Continued.

Citrus otahietiensis.
Cyclamen persicum.
Cissus discolor.
Clerodendron fallax.
Cypripedium insignis.
Cylogne cristata.
Curculigo recurvata.
Curmeria wallisii.
Crotons:
- Aurea maculata.
- Andreanum.
- Anitumensis.
- Angustifolia.
- Albo lineata.
- Albicans.
- Barryii.
- Barrone Jas. de Rothschild.
- Bergmanii.
- Brilliantissima.
- Chrysophyllos.
- Carrierii.
- Charmerii.
- Cronstadii.
- Disraelii.
- Dayspring.
- Duke of Buccleugh.
- Earlscourt.
- Evansianum.
- Fasciatus.
- Flamingo.
- Flambeau.
- General Paget.
- Hawkerii.
- Hanburyanus.
- Interruptum.
- Irregularii.
- Johannis.
- Lord Belhaven.
- Laingii.
- Lady Zetland.
- Lord Derby.
- Madame Seilliere.
- Mortii.
- Moreana.
- Mrs. Swan.
- Multicolor.
- Maximum.
- Mrs. Dormer.
- Musaicus.
- Morletii.
- Madame Chas. Heine.
- Madame Cappe.
- Marquess de Castellane.
- Newmannii.
- Nobilis.
- Orvilla.
- Queen Victoria.
- Rubra variegata.
- Rosea picta.
- Reidii.
- Sunshine.
- Sovereign.
- Superbus.
- Triumphans.
- Thompsonii.

Crotons—Continued:
- Undulatum.
- Volutum.
- Veitchii.
- Williamsii.
- Youngii.

Chrysanthemum:
- Mrs. Perrin.
- Helen Bloodgood.
- Col. W. B. Smith.
- Mrs. W. C. Egan.
- Modesto.
- V. Morrell.
- George Schlegel.
- The Queen.
- William Simpson.
- Edna Prass.
- Violescent.
- Golden Wedding.
- Frank Hardy.
- Maud Dean.
- Major Bonnaffant.
- Hon. W. Q. Gresham.
- Mrs. J. M. Wilson.
- Surprise.
- Glory of Pacific.
- Diana.

Crassula aurea.
Canna:
- Florence Vaughan.
- J. C. Vaughan.
- Madame Crozy.
- Alphonse Bouvier.
- President Cleveland.
- Mrs. Kate Gray.

Coleus:
- Golden Bedder.
- Verschaffeltii.
- Shylock.
- Golden Beauty.
- Souv. de rosa.
- Mephistopheles.

Cocoloba platyclada.
Calla:
- Ethiopica.
- Pentlandii.

Carnation:
- C. H. Crane.
- Ethel Crocker.
- Mrs. George H. Bradt.
- Gold Nugget.
- White Cloud.
- Melba.
- Glacier.
- Mrs. Lawson.
- Olympia.
- William Scott.

Carica quercifolia.
Cupsessus sempervirens.
Coffea arabica.
Cæsalpinia gillesii.
Dracena:
- Amabilis.
- Charles Dissel.
- Shepherdii.

List of tropical and semitropical plants, palms, ferns, flowering and bedding plants in the general collection of the propagating gardens—Continued.

Dracena—Continued.
Fraserii.
Terminalis.
Hendersonii.
Youngii.
Gladstonei.
Knuerkii.
Rumphii.
Lindenii.
Goldieana.
Bruantii.
Sanderiana.
Fragrans.
Bella.
Mrs. Twombly.
Dichorisandra undata.
Dieffenbachia eburnea.
Dasylirion longifolia.
Erythrina crista galli.
Echmea fulgens.
Euphorbia splendens.
triangulari.
Erica persoluta rubra.
melanthera.
Echeveria metallica.
rosacea.
agavoides.
secunda.
secunda glauca.
parvifolia.
mirabilis.
magnifica.
retusa florabunda.
mexicana.
Eulalia japonica variegata.
zebrina.
Ferns:
Adiantum cuneatum.
gracillimum.
concinnum latum.
cardiochlena.
Farleyense.
Ballii.
macrophyllum.
trapeziforme.
rhodophyllum.
Asplenium belangerii.
nidus avis.
Cibotium schiedei.
Davallia stricta.
mooreana.
Lastrea aristata variegata.
opaca.
Nephrodium molle.
Nephrolepis pectinata.
cordata nana compacta.
davallioides furcans.
Nephrolepis davallioides.
multiceps.
rufescens tripinnatifida.
Polypodium aureum.
Pteris serrulata cristata major.
voluta.
cretica alba lineata.
Ferns—Continued.
Pteris cretica.
victoria.
Ficus elastica.
Ficus elastica variegata.
Ficus repens.
Ficus macrophyllum.
Fourcroya lindenii.
Fittonia argyroneura.
Farfugium grande.
Gardenia florida.
Grabuskia glauca.
Hydrangea otaska.
Hedychium coronarium.
Iresine Lindenii.
Ipomia noctophyton.
Jasminum grandiflorum.
Imantophyllum miniatum.
Justicia carnea.
Jussiœa longifolia.
Laurus camphora.
Lilium Harrisii.
auratum.
longifolium.
Lycaste skinneri.
Lalia anceps.
Magnolia fuscata.
Musa variegata.
Myrsiphyllum asparagoides.
Nymphæa devoniensis.
marliacea chromatella.
candidissima.
zanzibariensis.
Ouvirandra fenestralis.
Olea fragrans.
Olea infrantore.
Panax laciniatum.
Panax victoria.
Panicum variegatum.
Peristeria elata.
Pancratium ovatum.
Pentas lanceolata.
Phyllotoenium lindenii.
Paullinia thalictrifolia.
Pellionia Daveauniana.
Peperomia metallica.
Peperomia Daveauniana.
Phyllanthus rosea picta.
Phyllanthus niveus.
Phyllogatus rotundifolia.
Plumbago capensis.
alba.
Poinsettia pulcherrima.
Piptadenia cebil.
Physianthus albens.
Primula obconica.
sinensis.
forbesii.
Palms:
Acanthophœnix crinita.
Areca lutescens.
Baueri.
Verschaffeltii.
Carludovica palmata.

List of tropical and semitropical plants, palms, ferns, flowering and bedding plants in the general collection of the propagating gardens—Continued.

Palms—Continued.
Carludovica incisa.
elegans.
Ceroxylon niveum.
Chamærops humilis.
excelsa.
Cocos weddelliana.
plumosa.
Corypha australis.
Calamus melanochetes.
Calumus lewisianus.
Cycas circinalis.
Cycas revoluta.
Dæmonorops palembanicus.
Kentia wendlandi.
Kentia sanderiana.
Kentia fosteriana.
Kentia australis.
Kentia canterburyana.
Kentia macarthuri.
Kentia belmoreana.
Licuala grandis.
Licuala peltata.
Latania borbonica.
Litania rubra.
Litania aurea.
Livistonia rotundifolia.
Pritchardia thurstonii.
Pritchardia pacifica.
Phœnix dactylifera.
Phœnix reclinata.
Phœnix rupicola.
Phœnicophorium seychellarum.
Ptychosperma alexandrae.
Seaforthia elegans.
Sabal blackburneana.
Thrinax parviflorus.
Thrinax argenteus.
Pinanga kuhlei.
Rhapis flabelliformis.
Rhaphis humilis.
Pelargoniums:
Admiral Dewey.
Meteor.
John Sogle.
Surprise.
Freedom.
Duc de Montemart.
Emile Lemoine.
J. S. Nutt.
General Grant.
La Favorite.
Madame Thibaut.
James Vick.
Pelargoniums—Continued.
Ernest Louth.
Pandanus veitchii.
Pandanus baptistii.
Pandanus caricosus.
Pandanus amaryllidifolia.
Roses:
Abel Carriere.
Barrone Prevost.
Bridesmaid.
Clotilde Soupert.
Crimson rambler.
Charles Lefebvre.
Coquette des Blanche.
Captain Christy.
Duchess of Edinburgh.
Earl of Dufferin.
Geant des Battailles.
Golden gate.
Jules Margottin.
Kaiserin Augusta Victoria.
Mme. Georges Bruant.
Mabel Morrison.
Madame Hoste.
Marion Dingee,
Mamon Cochet (pink).
(white).
Paul Neyron.
Perle des Jardin.
President Carnot.
Souv. de Wootton.
Liberty.
Ruellia daveauneana.
Schizmataglottis robbelinii.
Schizmataglottis siamensis.
Stephanotis floribunda.
Strelitzia regina.
Stevia serrata.
Stigmaphyllon ciliatum.
Stenandrum lindenii.
Sanseveira zelanica.
Spathophyllum hybridum.
Sibthorpia europea.
Solanum capsicastrum.
Salvia splendens.
Senicio scandens.
Selaginellas emileana.
Tradescantia zebrina variegata.
Vinca rosea.
Vinca alba.
Violet Maria Louise.
Violet Lady Hume Campbell.
Violet California.
Yucca alœfolia.

APPENDIX I I I.

NORTHERN AND NORTHWESTERN LAKES—CORRECTING AND ISSUING CHARTS—SURVEYS—WATER LEVELS.

REPORT OF LIEUT. COL. G. J. LYDECKER, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1900.

I I I 1.

United States Engineer Office,
Detroit, Mich., August 15, 1900.

General: I have the honor to submit herewith my annual report on survey of the Northern and Northwestern Lakes for the fiscal year ending June 30, 1900.

Very respectfully, your obedient servant,

G. J. Lydecker,
Lieut. Col., Corps of Engineers.

Brig. Gen. John M. Wilson,
Chief of Engineers, U. S. A.

NORTHERN AND NORTHWESTERN LAKES -CORRECTING AND ISSUING CHARTS—SURVEYS—WATER LEVELS.

The survey of the lakes as a connected and systematic work was commenced in 1841 and completed in 1882, but local surveys by officers of engineers for special purposes, including harbor improvements, date back to 1817. After the general survey was completed, in 1882, operations were limited to the publication and issue of the Lake Survey Charts until 1889, under annual appropriations of two or three thousand dollars, but from the last-mentioned date additional appropriations, varying from five to twenty-five thousand dollars, were made annually for surveys relating to additions to and corrections of the original charts. In 1898 these operations were extended to include observations and investigations of lake levels, with a view to ascertaining the causes of changes in level, determining the hydraulic data needed for formulating the laws of interlake flow, and devising the most feasible method of lake level maintenance or regulation.

Operations during the last fiscal year have included work related to the several features above referred to, as follows:

Charts.—The following statement shows the number received and disposed of at this office:

Description.	Number.	Total.
On hand July 1,1899	5,728	
Received during the year	6,902	
Total on hand and received		12,630
Sold at 31 cents each	23	
Sold at $30\frac{2}{3}$ cents each	16	
Sold at 27 cents each	302	
Sold at $26\frac{2}{3}$ cents each	295	
Sold at 25 cents each	42	
Sold at 24 cents each	34	
Sold at $23\frac{3}{5}$ cents each	66	
Sold at 23 cents each	1,158	
Sold at 20 cents each	4,559	
Sold at 7 cents each	27	
Sold at $6\frac{1}{2}$ cents each	14	
Issued to United States vessels and for official use	358	
Destroyed, worthless, not having corrections to date	272	
Total disposed of		7,166
On hand July 1, 1900		5,464

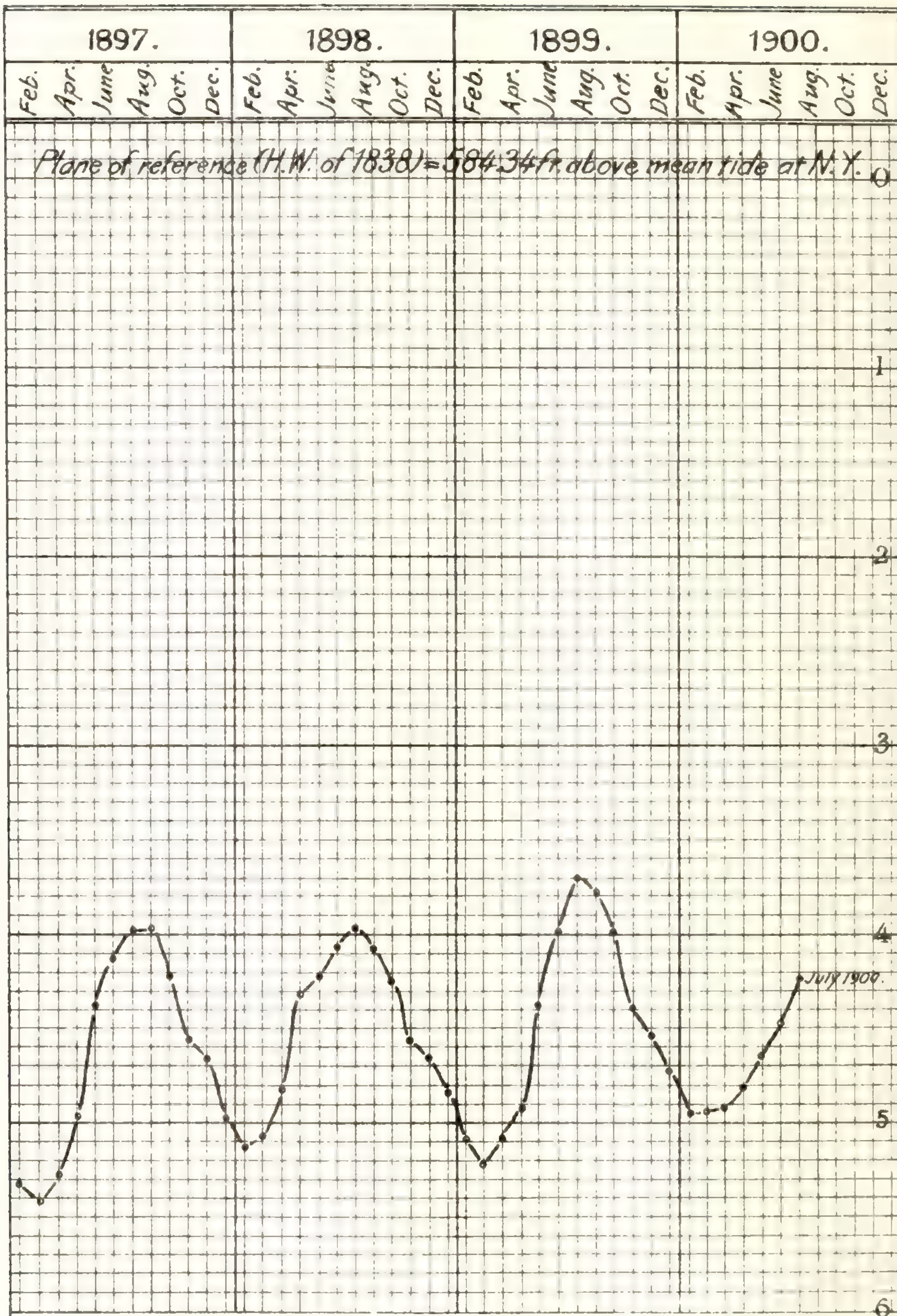
The total number of charts sold during the year was 6,536, the total amount received from these sales being $1,387.53, which was duly deposited to the credit of the Treasurer of the United States. The total number of charts that have been disposed of through this office to June 30, 1900, is 231,176.

Corrections and additions were made to old charts in this office during the year as follows:

Sandusky Bay.
Coast Chart No. 6, Lake Erie.
Coast Chart No. 7, Lake Erie.
Detroit River.
Lake St. Clair.
Lake Huron.
Straits of Mackinac.
Beaver Island Group.
North End of Green Bay.
South End of Green Bay.
North End of Lake Michigan.
South End of Lake Michigan.
General Chart of Lake Michigan.
Coast Chart No. 4, Lake Michigan.
Coast Chart No. 5, Lake Michigan.
General Chart of Lake Superior.
St. Marys River, No. 2.
St. Marys River, No. 3.

These corrections and additions (which were also made on the engraved plates in the Office of the Chief of Engineers) included changes in aids to navigation, modifications due to river and harbor improvements, latest magnetic determinations, additional and corrected sailing courses, and the most prominent topographic or hydrographic changes developed by commercial and industrial enterprise on the shores of the lakes and their tributary and connecting rivers. Much office work was applied to incidental changes of individual charts by hand, preparatory to sale or issue, in cases where the last edition as printed did not supply the latest authentic information.

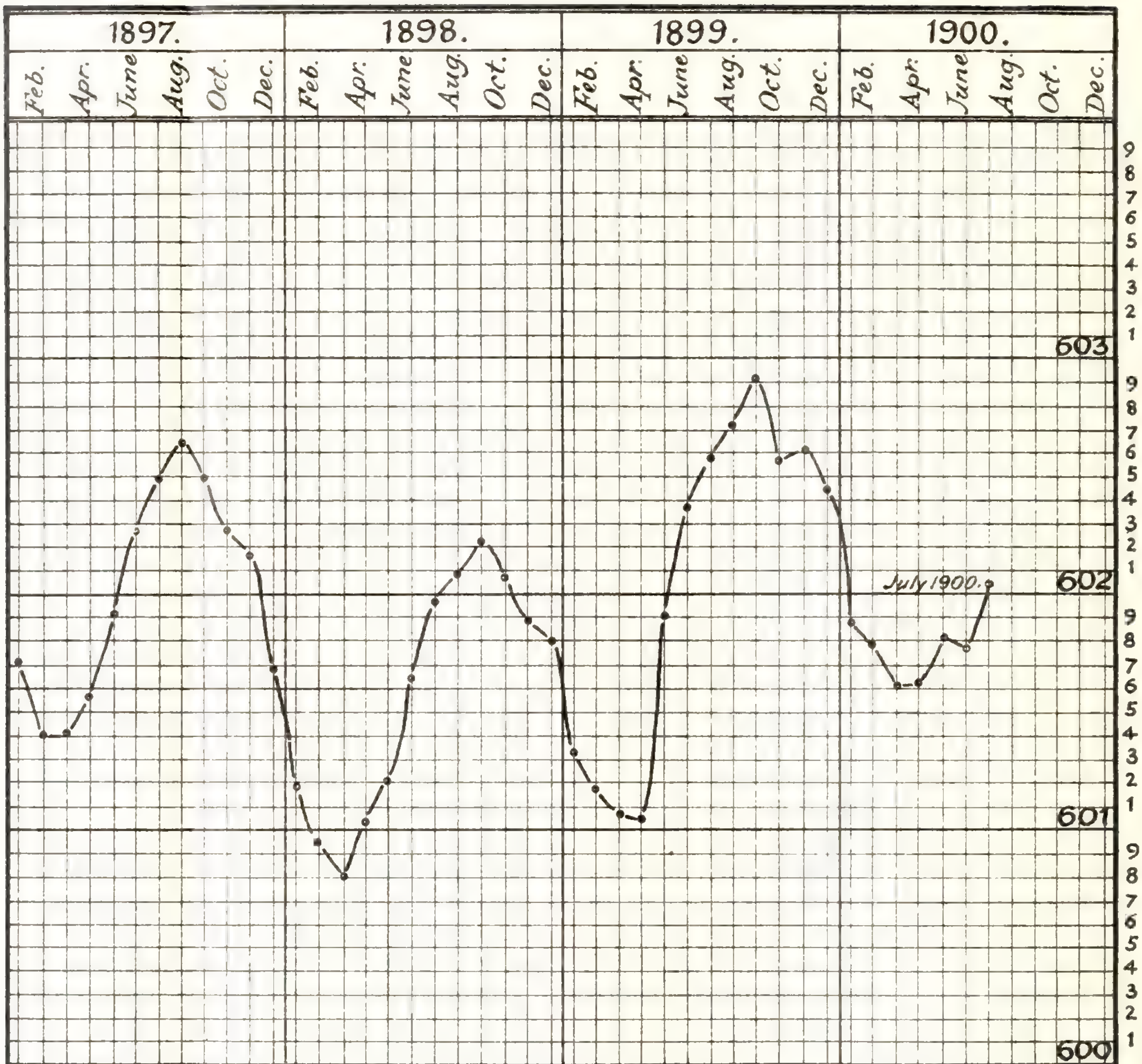
In addition to correcting old charts, new ones were prepared and issued as follows: St. Marys River, No. 1 (completing the set of three covering the waterway from Lake Superior to Lake Huron), and Chart No. 1 of the Apostle Islands locality in Lake Superior. Work on new chart, No. 2, of the same locality was nearly completed. The new charts are all printed in colors, and the substitution of such charts for



ANNUAL WATER LEVEL CURVE AT
SAND BEACH, LAKE HURON
reduced from monthly means of Noon readings.

Transmitted with my annual report for the fiscal year ending June 30th 1900.

Lieut. Col. Corps of Engineers.



ANNUAL WATER LEVEL CURVE, LAKE SUPERIOR.

Platted from observations taken "above the Locks" at

St. Marys Falls Canal, Mich.

The water level curve shows the elevation of the surface of the Lake above mean tide at New York. The mean elevation for each month is platted.

Transmitted with my annual Report for the fiscal year ending June 30th 1900.

Lieut. Col. Corps of Engrs.

the finely engraved ones formerly issued continues to be highly satisfactory to vessel masters, for they show at a glance the characteristic depths of water areas as respects safe or unsafe navigation for vessels of light or deep draft. It is therefore desirable that all charts hereafter issued be of this character, and that the change be brought about as soon as practicable.

Water levels.—The elevation of the water surface of Lake Huron has been recorded, as heretofore, by tridaily readings of the gauge at Sand Beach Harbor of Refuge, and similar record has been kept respecting the Upper St. Marys River by gauge at the head of the Government canal at Sault Ste. Marie, Mich. The following table shows the monthly means for the year derived from these records:

Monthly means of water level for Sand Beach and Sault Ste. Marie, expressed in feet below the plane of reference adopted in 1876.

Station.	1899.						1900.					
	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.
Sand Beach	3.70	3.79	3.99	4.40	4.54	4.73	4.96	4.95	4.92	4.80	4.65	4.48
Sault Ste. Marie	2.19	2.04	1.85	2.19	2.15	2.31	2.88	2.97	3.15	3.14	2.94	2.98

The accompanying plats illustrate the varying stages of water as shown by like records for the last five years.

Investigation of lake levels.—The general project for this investigation is printed in the Report of the Chief of Engineers for 1898, pages 3774–3776, and operations to June 30, 1899, are outlined in the Report for that year, pages 3853, 3854.

During the last fiscal year field work was continued on the Niagara and St. Clair rivers until the middle of December, when operations were suspended for the winter. Work on the Niagara was resumed June 18, 1900, for the special purpose of making some discharge measurements during the annual high-water period in Lake Erie, but lack of funds prevented any further field work in the St. Clair until after the close of the year. During the time that field work was suspended the office force was busily engaged in reducing and platting observed data and in making an elaborate analysis of the results obtained. The principal results were the determination of 269 vertical and 254 horizontal velocity curves for the Niagara River, covering a range of 4 feet on the Lake Erie gauge at Buffalo. The total number of discharges measured, reduced, and platted was 153. For the St. Clair River 245 vertical and 245 horizontal velocity curves were determined, covering a range of 1.7 feet in the Lake Huron water stage, the total number of discharges measured, reduced, and platted being 90. In addition to velocity measurements careful determinations were made of river slope corresponding to varying stages of water in the lakes and to changes in the direction and force of wind, and a great many soundings were made with the utmost precision. As a result of work done to June 30, 1900, the discharge of the Niagara River is found to vary from 155,000 cubic feet per second to 240,000 cubic feet per second, corresponding to elevations of the Lake Erie water surface at Buffalo of 569.7 and 573.6 feet, respectively, above mean tide at New York; and the discharge of the St. Clair River at Port Huron is found to be 179,000 cubic feet per second when Lake

Huron is at an elevation of 579.17 feet, and 211,500 feet per second when the Lake Huron elevation is 580.87 feet. These results will be found to vary with changing local conditions, especially such as result from the effects of ice or the direction and force of wind. In my last Annual Report (page 3854, Report Chief of Engineers for 1899) I stated that we had found indications of a marked deepening since 1867 in the channel of the St. Clair River just below its head, and it was thought that this might have caused a material change in the outflow from Lake Huron during recent years; but further careful investigation shows clearly that there has been no such change in the regimen of the river. It also shows the great danger of jumping to conclusions in matters of this kind, and suggests the propriety of avoiding an expression of opinion on any important point until all the facts in the case are positively ascertained.

Subreports are submitted herewith which supply most detailed and interesting information relating to the investigations so briefly outlined above, as follows: Report by Assistant Engineer E. E. Haskell, who had supervision of the whole; report by Assistant Engineer F. C. Shenehon, in immediate charge of operations on the Niagara River; and report by Assistant Engineer L. C. Sabin, in immediate charge of operations on the St. Clair River.

This work is now well organized and it should be steadily pursued with all possible dispatch. In order to do so provision should be made for an expenditure of at least $50,000 for field and office work during the year ending June 30, 1902.

A matter of equal or perhaps greater importance is the early correction and extension of our charts, so as to make them show the natural and artificial changes which have taken place; adapt them to the deeper draft of vessels now engaged in lake commerce, and have them show the reduced depths of water which now prevail during the navigable seasons. The original charts were prepared with reference to a navigation calling for a draft of only 12 feet. The soundings were referred to planes representing a mean or average stage of water, and general depths exceeding 18 feet below such planes were not closely exploited; but present conditions of commerce demand that the bottom be now accurately charted to depths of not less than 30 feet in the open lakes or 25 feet in their connecting rivers or straits, and these depths should relate to ordinary "low-water" stages, instead of to the "mean stage" referred to above. This will call for extensive surveys and a vast amount of office work, all of which must be done with great care and accuracy. This work will be inaugurated with a considerable force during the current fiscal year under the appropriation made by the sundry civil act of June 6, 1900, and means should be supplied to carry it to completion as rapidly as possible. An expenditure of $150,000 during the year ending June 30, 1902, will be necessary for such reasonable progress as the circumstances of the case require. I therefore recommend and, so far as permissible, urge that the appropriation for the year 1902 be made to cover the two amounts above indicated, as follows:

For survey of northern and northwestern lakes, including all expenses of correcting, extending, and issuing charts, and of investigating lake levels, with a view to their regulation, to be available until expended, two hundred thousand dollars.

Money statement.

July 1, 1899, balance unexpended	$34, 600. 99
Amount allotted from act of June 6, 1900	72, 000. 00
	106, 600. 99
June 30, 1900, amount expended during fiscal year, including $5,000 paid by Treasury Department to Navy Department in part payment of steamer *Enquirer*	32, 926. 42
July 1, 1900, balance unexpended	[1]73, 674. 57
July 1, 1900, outstanding liabilities	1, 603. 15
July 1, 1900, balance available	72, 071. 42

Dates and amounts of appropriations for survey of Northern and Northwestern Lakes.

March 3, 1841	$15, 000	March 2, 1868	$77, 500
March 18, 1842	20, 000	July 20, 1868	75, 000
March 1, 1843	30, 000	March 3, 1869	100, 000
June 17, 1844	20, 000	July 15, 1870	100, 000
March 3, 1845	20, 000	March 3, 1871	175, 000
August 8, 1846	25, 000	June 10, 1872	175, 000
August 12, 1848	25, 000	March 3, 1873	175, 000
March 3, 1849	10, 000	June 23, 1874	175, 000
September 28, 1850	25, 000	March 3, 1875	150, 000
March 3, 1851	25, 000	July 31, 1876 (not including $16,000 applied to survey of Mississippi River)	84, 000
August 30, 1852	25, 000		
March 3, 1853	50, 000		
August 5, 1854	50, 000	March 3, 1877 (not including $25, 000 applied to survey of Mississippi River and including $9,500 received from sale of steamers)	94, 500
March 3, 1855	50, 000		
August 30, 1856	50, 000		
March 3, 1857	50, 000		
June 12, 1858	75, 000		
March 3, 1859	75, 000	June 20, 1878 (not including $49,500 applied to survey of Mississippi River)	49, 500
June 21, 1860	75, 000		
March 2, 1861	75, 000		
July 5, 1862	105, 000	March 3, 1879	85, 000
February 9, 1863	106, 879	June 16, 1880	40, 000
July 2, 1864	100, 000	March 3, 1881	18, 000
February 28, 1865	125, 000	August 7, 1882	12, 000
June 12, 1866	50, 000		
March 2, 1867	77, 500	Total	2, 939, 879

Printing and issue of charts for use of navigators, and electrotyping copperplates for chart printing.

March 3, 1883	$3, 000	March 3, 1893	$2, 000
July 7, 1884	3, 000	August 18, 1894	2, 000
March 3, 1885	3, 000	March 2, 1895	2, 000
August 4, 1886	2, 000	June 11, 1896	2, 000
March 3, 1887	2, 000	June 4, 1897	2, 000
October 2, 1888	2, 000	July 1, 1898	3, 000
March 2, 1889	2, 000	March 3, 1899	3, 000
August 30, 1890	2, 000	June 6, 1900	3, 000
March 3, 1891	2, 000		
August 5, 1892	2, 000	Total	42, 000

Surveys and additions to and correcting engraved plates.

March 2, 1889	$5, 000	June 11, 1896	$25, 000
August 30, 1890	10, 000	June 4, 1897	25, 000
March 3, 1891	10, 000	July 1, 1898	25, 000
August 5, 1892	5, 000	March 3, 1899	25, 000
March 3, 1893	25, 000	June 6, 1900	75, 000
August 18, 1894	25, 000		
March 2, 1895	25, 000	Total	280, 000

[1] In addition to this balance reported by Lieutenant-Colonel Lydecker there remains of this appropriation unexpended the sum of $9,562.28.

REPORT OF MR. E. E. HASKELL, ASSISTANT ENGINEER.

United States Engineer Office,
Detroit, Mich., July 16, 1900.

Colonel: I have the honor to make the following report of progress upon work pertaining to the investigation of lake levels, survey of northern and northwestern lakes, for the fiscal year ended June 30, 1900:

The project for this investigation is given in your annual report for 1898, beginning on page 3774 of the Report of the Chief of Engineers for that year, and attention is invited thereto for a general statement of the work contemplated.

In my last Annual Report, beginning on page 3856 of the Report of the Chief of Engineers for 1899, is a statement of the condition of the work at the close of the last fiscal year. Briefly speaking, precise levels had been run from St. Regis to Cape Vincent on the St. Lawrence River, and from Lake Erie to Lake Huron along the Detroit and St. Clair rivers. Gauging operations had been in progress on the Niagara since the previous September, on the St. Clair since the previous November, with about three months' observations during the winter on the St. Marys River.

GENERAL PROGRESS DURING THE YEAR.

During the past year the gauging work upon the Niagara River was continued until December 15, when operations were suspended for the winter. They were resumed June 18, and are now in progress for the express purpose of obtaining measurements during the annual period of high water in Lake Erie, which occurs in June–July.

Gauging operations were continued upon the St. Clair River at Port Huron until the middle of December, when they were suspended for the winter. They have not been resumed at this writing, although more data is desirable, and especially measurements made during the winter months when Lake St. Clair and the lower end of the St. Clair River are frozen over.

Gauging operations were in progress on the St. Marys River during the month of December, the measurements being made from the International Bridge. The hydrographic work in progress in Potogannissing Bay at the close of the last fiscal year was completed the latter part of July and the soundings reduced and platted immediately, these being required for the new chart, No. 1, of St. Marys River.

A very satisfactory report can be made of the operations of the 13 self-registering water gauges, and a considerable amount of valuable data have been collected by them.

NIAGARA RIVER DISCHARGE MEASUREMENTS.

The Niagara River work was under the immediate charge of Mr. F. C. Shenehon, assistant engineer, who, during the winter and spring has made a reduction of all of the observations so far collected, with a report setting forth the results obtained. This report is hereto appended, and will be found to contain a great deal of information of value in relation to the hydraulics of this river and to methods for the gauging of streams.

The precision attained in this work, as also the remainder of our gauging work, is worthy of special mention. For reasons stated in my last annual report the measurements of the Niagara began from the International Bridge and were continued from this structure until about the end of July, when the outfit for open-river work was available. A new cross section was then located about 1,800 feet downstream from the bridge and measurements were made at this section until the close of the field season in December, and resumed at it with the beginning of field operations last month. We thus have two distinct cross sections, 1,800 feet apart, at which discharge measurements of the Niagara River have been measured with equal care. The agreement between the discharge curves for the two sections can best be judged by reference to either plates 3 or 4 of Mr. Shenehon's report. It will be found to be most satisfactory.

Since the high water of 1838 the water surface of Lake Erie has fluctuated through a maximum range of 4.41 feet—from 575.20 down to 570.79, reckoned in feet above mean tide at New York. Mr. Shenehon's measurements from the bridge cover approximately 1 foot of this range when the lake is quiescent; from 571.25 to 572.25, with measurements during storms for some distance both above and below these limits. Similarly the open-section work covers approximately the range from 570.75 to 571.75, with measurements during storms both above and below these limits. In the case of the bridge observations Mr. Shenehon has drawn the most probable curve passing through them, and in the case of the open-section observations the most probable straight line passing through them. It is very probable that outside

of the limits of the actually quiescent stages, which our observations cover, our curves may be slightly in error, and they should therefore be used with caution until such times as they can be verified by observations made when the lake surface is actually at these higer or lower stages.

It is hardly necessary for me to review Mr. Shenehon's work, for he has given his methods and results in detail, and your attention is invited to his report for these.

I wish to call your especial attention, however, to that part of Mr. Shenehon's report describing what we have termed our "2-meter" and "3-meter" methods. Excellent use has been made of these, and they are certainly great improvements over the old style of using 1 meter in discharge work. It may be possible that for small pieces of gauging one or the other of these methods is a happy medium between the old style and our more expensive multiple-meter set. Mr. Shenehon has demonstrated that the gauging party can operate two or three meters simultaneously with but little more labor than required for one, while the value of the results obtained are greatly enhanced.

It will be observed that the results obtained by Mr. Shenehon for the discharge of the Niagara are somewhat smaller than those given by the Board of Engineers on Deep Waterways, as published by Mr. C. B. Stewart in his paper on "Discharge Measurements of Niagara River," read before the Western Society of Engineers, in December, 1899. The greater part of this difference comes from our having very much more data upon which to base the determination of the coefficients used in the reductions. The remainder comes from the smaller value used for the cross section, this having been measured with more elaborate appliances by Mr. Shenehon, and hence with greater precision than I could attain with the outfit at my disposal when I started the work for the Board. I mention this so there can be no misunderstanding regarding the values obtained by the Board and those published by this office.

ST. CLAIR RIVER DISCHARGE MEASUREMENTS.

The St. Clair River work was under the immediate charge of Mr. L. C. Sabin, assistant engineer, who, during the interval since the close of field work in December, has made a reduction of all of the observations so far collected, with a report giving the results obtained. This report is hereto appended and contains much valuable data relative to the hydraulics of the St. Clair River, and to methods of gauging open channels.

It is hardly necessary for me to repeat the results obtained by Mr. Sabin, for his report deals with them in detail and your attention is invited thereto. In passing, however, I wish to emphasize two features, namely, the use to be made of his discharge curve for the St. Clair River, and the success attained with the multiple-meter set.

Since the high water of 1838 Lake Huron has fluctuated through a maximum range of 5.76 feet—from 584.34 down to 578.58, reckoned in feet above mean tide at New York. Mr. Sabin's observations made when Lake Huron was quiescent, cover approximately 1.22 feet of this range—from 579.42 to 580.64, with observations during storms both above and below these limits. Mr. Sabin has drawn for the discharge curve the most probable straight line passing through these observations, and, as will be seen by inspection (Pl. XI of his report), it is as satisfactory as any curve that could be run through them. Caution should be observed, however, in making use of this line beyond the limits, until such time as the flow of the St. Clair can be actually measured when Lake Huron is at higher stages.

Within the range of our observations we are now able to state with definiteness the result to be expected from the withdrawal at Chicago of 10,000 second-feet of water from Lake Michigan for sanitary purposes. Mr. Sabin gives the results of his computation on the matter, and I need not repeat them. To those people interested in this problem I feel sure this information will be welcome.

The work of the multiple-meter set is nicely illustrated in the vertical curves shown on Pls. IV and V. This method of obtaining them has been very satisfactory indeed, and with increased experience in handling so large a number of meters at one time will prove of still greater value.

In my last year's report I called attention to what seemed at that time a clear case of enlargement, by scour, of the head of the St. Clair River. A preliminary survey of this reach was made by Mr. Sabin in December, 1898. The results of this survey, when compared with the chart of the survey of 1867, showed what seemed to be a cutting out of the river bed to a depth about 18 feet greater, for an area covering a portion of the gorged reach. Upon the strength of this evidence I made the statements that appear in my last Annual Report. Early last fall Mr. Sabin called my attention to the fact that the survey of 1859 of this reach, as charted, agreed much

closer with present conditions than did the survey of 1867. It immediately occurred to me that it would be well to secure the original field notes of the surveys of 1859 and 1867 and replat them on the same scale as the detailed survey made last fall, and then compare the three surveys. Accordingly, the old notes were obtained and the surveys of 1859 and 1867 platted anew on a scale of 1:5000, putting on all soundings taken. Tracings of these new plats were sent to Mr. Sabin and he was requested to make a very careful comparison of these with the results of his recent work. He has accomplished this, and discusses the matter very carefully in his report. His conclusions are that the changes that have taken place are small, that between 1859 and 1867 the most restricted cross section may have enlarged about 9,000 square feet, and that the line of deepest water may have moved a little westward; that between 1867 and the present time the changes, if any, are unimportant. What seemed at the outset, therefore, as a reasonable explanation for the low stage of water in Lakes Huron and Michigan, culminating in 1895, is set at naught, and we must return to the question of rainfall and evaporation for new data for a satisfactory solution.

ST. MARYS RIVER DISCHARGE MEASUREMENTS.

The St. Marys River work was under the immediate charge of Mr. Thomas Russell, assistant engineer. During December Mr. Russell measured 34 complete discharges from the International Bridge. These have been reduced, and the reduction of the discharges measured by Mr. Russell during the fiscal year 1899, as described in my last annual report, has been finished. The results from these measurements have not been prepared for publication, in the hope that more data might be obtained in the near future, when a more complete report might be submitted.

In addition to the above, Mr. Russell completed about July 20 the hydrographic work in Potogannissing Bay he had in hand at the close of the last fiscal year, and after his return from the field reduced and platted the soundings obtained in this survey.

During the year Mr. Russell has also collected and reduced a considerable amount of rainfall data of the Great Lakes Basin, extending previous information, all of which will be presented for publication after a thorough discussion.

THE OPERATION OF SELF-REGISTERING WATER GAUGES.

Three new self-registering gauges were established on Lake Ontario, in August last, by Mr. David Molitor, assistant engineer. Mr. Molitor also established a new gauge at Sault Ste. Marie, Mich., above the locks, in October. These, with the number established during the previous fiscal year, make 13 now in operation, with 2 yet to be located—one at Sault Ste. Marie, below locks, and the other at Chicago.

The gauges now running are located as follows, beginning at the lower end of the chain of lakes and counting upward: Tibbets Point, head of St. Lawrence River; Oswego and Olcott, on Lake Ontario; Niagara River at foot of Squaw Island; Buffalo Breakwater; Amherstburg, Ontario, mouth of Detroit River; Windmill Point, Mich., head of Detroit River; Roberts Landing, Mich., head of delta, St. Clair River; three in vicinity of the head of St. Clair River; Mackinaw City, Mich., and Sault Ste. Marie, Mich. I would earnestly recommend the extension of this system to include Cleveland, Harbor Beach, Milwaukee, Marquette, and Duluth, with a gauge for the interval of one year at both Detour and Point Iroquois. The five former are needed for our records of lake stages, while the records of the two latter are required for transference of water levels across Lakes Huron and Superior in our chain of new levels.

All of these gauges have been giving a satisfactory record, and as a sample I append Plate No. 1, which is a reproduction on one-half scale of the record of gauge No. 5, from 4 hours to 16 hours, of May 17, 1899. This gauge is located at the very head of the St. Clair River. This record shows what occasionally occurs at this point, and also illustrates the ease with which at times a vessel drawing 18 feet can strike in a 20-foot channel.

The record sheets from these gauges have nearly all been read and the results tabulated. I have not prepared these for publication, however, for the reason that it has seemed to me advisable to wait until they can be referred to our revised levels.

DESCRIPTION OF OUTFIT.

As it was necessary to create a considerable outfit for the prosecution of this work, and as this has now been in actual service upward of a year and a half and given satisfaction in every particular, it may prove of interest to describe the more important features.

Current meters.—The current meters were those designed by the writer about fourteen years ago. They belong to the screw wheel class, and two forms of them, known

as A meters and B meters, have been in use. The A meters are direction-current meters, while the B meters measure velocity only. They can best be judged by the work actually done with them, which I leave you to infer.

Catamarans.—The use of catamarans with air-tight steel hulls joined by steel trusses from which to work with the meters was your suggestion. Plate No. 2 presents a good view of one of the three accordingly designed for use in this work. Mr. David Molitor, assistant engineer, made the drawings and worked out the details of construction for them. The hulls are 29 feet 8 inches long over all, 5 feet 3½ inches beam, joined by four trusses holding them 16 feet apart, center to center. They are so constructed that they can be taken apart on the line of their guards for the purpose of cleaning and painting to protect from rust. There are water-tight bulkheads 5 feet from the bow and 3 feet from the stern, dividing each hull into three compartments. Each hull has a manhole in its deck large enough for a man to pass through into the central or largest compartment. The manhole cover has a plug in its center and there is a similar plug over each of the smaller compartments, all of which can be removed for the purpose of inserting a small pump for clearing leakage should any occur. There has, however, been no trouble from this cause so far.

The trusses joining the hulls carry a deck that is 17 feet wide by 16 feet fore and aft. Placed on the forward part of this deck is a hand-power windlass for heavy pulling required at times on lines to lift anchors or to pull into position on a station. A house 10 feet square in plan by 7 feet high is centrally placed on the after part of this deck. This house is made in sections and removable at will. Plate No. 3 shows one of the catamarans with house removed in actual service in the strong current on the open section of the Niagara River work. Within the house is placed a stove for heat when required for comfort, the steering wheel for guiding the catamaran, reel for hoisting and lowering meters, appliances for operating multiple meter set, and tables for convenience of observing and keeping notes. The reel for hoisting and lowering meters was specially designed for this work. It can be used to handle a single meter or the multiple set of 11. It is provided with a depth register for indicating the position of the meter or a sounding weight in taking soundings. For using a single meter the drum of the reel carries a single cable which leads over a pulley in the top of the house and is then attached to the meter which passes through a trapdoor in the deck to reach its position in the water. To handle the multiple meter set, the reel is provided with two cables wound on the same drum. These lead in the same direction as the single cable and both are attached to a heavy mushroom anchor. Between these two cables the 11 meters of the multiple set are held, can be set at any distance apart, usually the tenths of depth, and all run simultaneously, thus observing a complete vertical curve in the time required to make a single observation.

The catamarans were further provided with a sounding reel, which consisted of a buggy wheel 10 feet in circumference, having a flanged tire. This wheel was provided with a crank and a movable index and had its circumference marked in feet and tenths. The sounding line used on it is a No. 16 phosphor bronze wire and the sounding leads are fish-shaped cast-iron weights of 15, 30, and 45 pounds, as occasion requires. The movable index is set at zero, when bottom of sounding weight is at surface of water. Depths can then be read off by noting revolutions of wheel and reading of index.

This reel works well for soundings in shallow water, or greater depths where there is no current. In the deep and swift water of the rivers, however, where a very heavy sounding weight is required, the meter reel with wire for sounding line is more satisfactory.

The method of handling the meters from the catamarans without the house on them is well illustrated on Plate No. 3 and hardly requires further description than is given by Mr. Shenehon in his report.

For handling the catamarans and attending to the necessary transportation of men in the gauging work, each party was provided with a small tug. A description of these is hardly necessary, further than to state that they are each provided with steam capstans for the heavy hauling on lines and the rapid lifting of anchors.

Self-registering water gauge.—The self-recording water gauge in use was designed by the writer in March, 1898, and has been named the "United States Lake Survey self-registering water gauge." It is the result of my experience in the use of such instruments while an assistant in the United States Coast and Geodetic Survey. In many respects it resembles instruments of its kind that have been in the market for some time. In a few respects innovations have been introduced for the purpose of making a more suitable instrument.

Plates Nos. 4 and 5 present two views of the gauge. Its dimensions are 14½ by 30½ inches in plan and 10½ inches high. It uses paper that is 16 inches wide and can be set to record on a scale of 1 inch to 1 foot, 1½ inches to 1 foot, or 3 inches to 1 foot, as desired. It has two clocks, one for driving the paper, shown in Plate No.

4, and one for keeping time and marking it on the paper, shown in Plate No. 5. Credit for this feature of two clocks is due to Mr. F. M. Little, of the tidal division of the Coast and Geodetic Survey. The use of the second clock makes a very valuable adjunct to the gauge, but I have made use of it in a little different form than suggested by Mr. Little, as will be seen by reference to Appendix No. 7 of the Coast and Geodetic Survey Report for 1897, by Mr. J. F. Pratt, assistant. On the Lake Survey gauge the time is marked by two pencils instead of one. The sharp jog in the serrated lines on the edges of the paper marked "Traced by time pencils"—see Plate No. 1—marks the hour. A straight line joining corresponding jogs on opposite sides of the sheet passes through the point of the stage pencil and hence marks the hour on the "stage" curve.

The datum pencil can be set at will to record the elevation of the zero of the gauge or any reading required.

Plate No. 1, with the lettering, the lines marked 578, 579, and 580 feet, and the hour lines 4 to 16, inclusive, left off, would show an actual record from a gauge.

The distributing and receiving rollers are designed to make the placing of a roll of paper in the instrument and the taking of one out a convenient and simple matter. The paper does not have to be "wound on" and "off" of rollers.

Ball bearings have been introduced in the instrument, wherever it was advisable, to reduce friction. These have proved very satisfactory and render the gauge very sensitive in recording "stage" of water.

In conclusion I wish to express my appreciation of the untiring efforts of Assistant Engineers Shenehon, Sabin, and Russell to accomplish not alone a large amount of work during the year, but also work of a very high order. The precision attained is very gratifying to me and illustrates what can be done in this class of work. It can in no way be considered accidental, for substantially the same accuracy has been attained on both the St. Clair and Niagara rivers.

Very respectfully, your obedient servant,

E. E. Haskell,
Assistant Engineer.

Lieut. Col. G. J. Lydecker,
Corps of Engineers, U. S. A.

REPORT OF MR. F. C. SHENEHON, ASSISTANT ENGINEER.

United States Engineer Office,
Buffalo, N. Y., July 18, 1900.

Sir: The outflow of the Niagara River affects the surface levels of all the Great Lakes except Superior, together with the connecting waters of all, involving at the extreme west St. Marys River and at the east the St. Lawrence.

In any project to maintain lake and interlake channels of uniform depth in all seasons and years by regulating weirs this river therefore holds a pivotal position.

The interests of the vast lake commerce demand permanent channels that will not shallow up with a dry season, that are just as deep in December as in June, and are invariable year in and year out.

Is it practicable to hold in check these seasonal and yearly rises and falls of the water level by intelligent human control of the outlets and realize this demand?

If so, its execution is a clear business proposition.

The feasibility of the control of Lake Erie, at least, hinges on the Niagara River, its volume, and the laws of its flows.

The hydraulics of this stream are therefore worthy of elaborate study and investigation, to measure the possibilities of regulation and to establish a basis for the design of regulating works.

With these ends in view the Board of Engineers on Deep Waterways made a series of observations on the discharge and slope of the river under the general charge of Mr. E. E. Haskell, Mem. Am. Soc. C. E., in 1897 and 1898, the latter year under my immediate charge as resident engineer.

When the Lake Survey succeeded to this task the previous work needed verification and extension. It fell heir to the equipment of the Board, which was adapted for work from the International Railway Bridge, and in addition to several months' experience in the detail of gauging a stream of great volume, deep, rapid, and difficult.

To the inherited outfit the Lake Survey added the current meter 2 B, and early in September, 1898, began taking discharge measurements from the bridge on the same general lines as had been followed by the Board.

Discharge observations were continued through the fall and into December until ice fields interrupted the work.

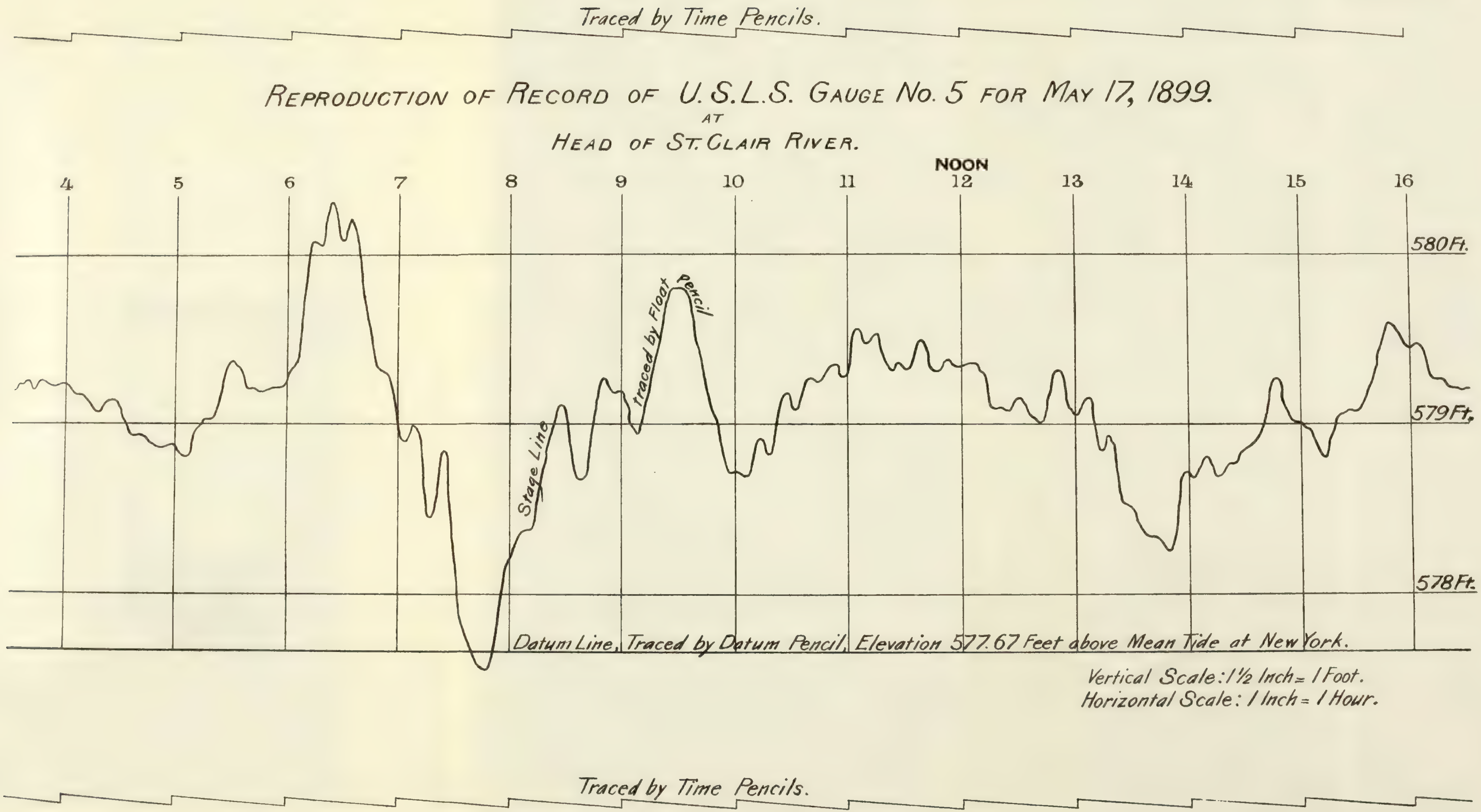
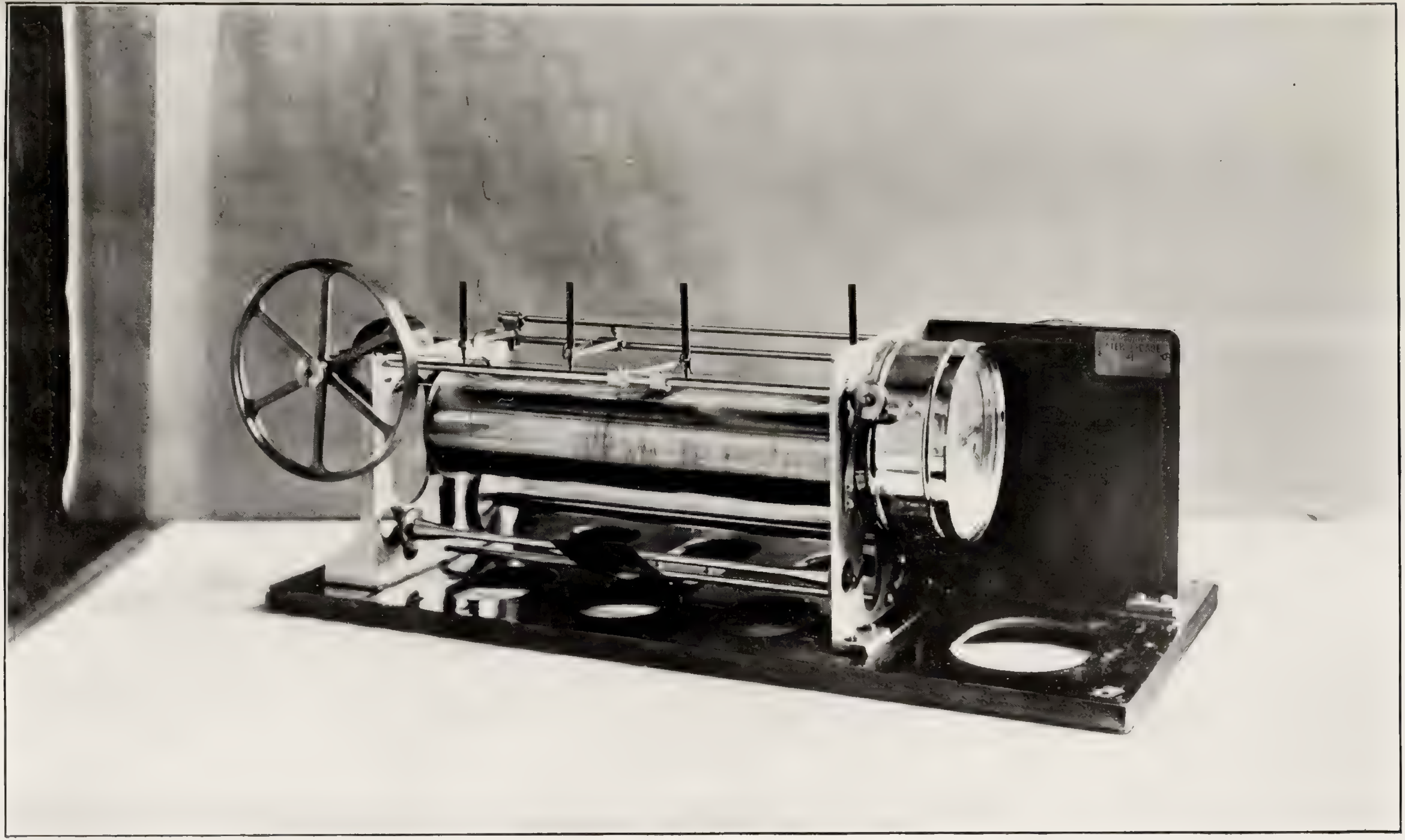

Traced by Time Pencils.
REPRODUCTION OF RECORD OF U.S.L.S. GAUGE No. 5 FOR MAY 17, 1899.
AT
HEAD OF ST. CLAIR RIVER.
NOON
4
5
6
7
8
9
10
11
12
13
14
15
16
580 Ft.
579 Ft.
578 Ft.
traced by Float Pencil
Stage Line
Datum Line, Traced by Datum Pencil, Elevation 577.67 Feet above Mean Tide at New York.
Vertical Scale: 1½ Inch = 1 Foot.
Horizontal Scale: 1 Inch = 1 Hour.
Traced by Time Pencils.

PLATE No. 2

CATAMARAN
for
Current Meter Observations

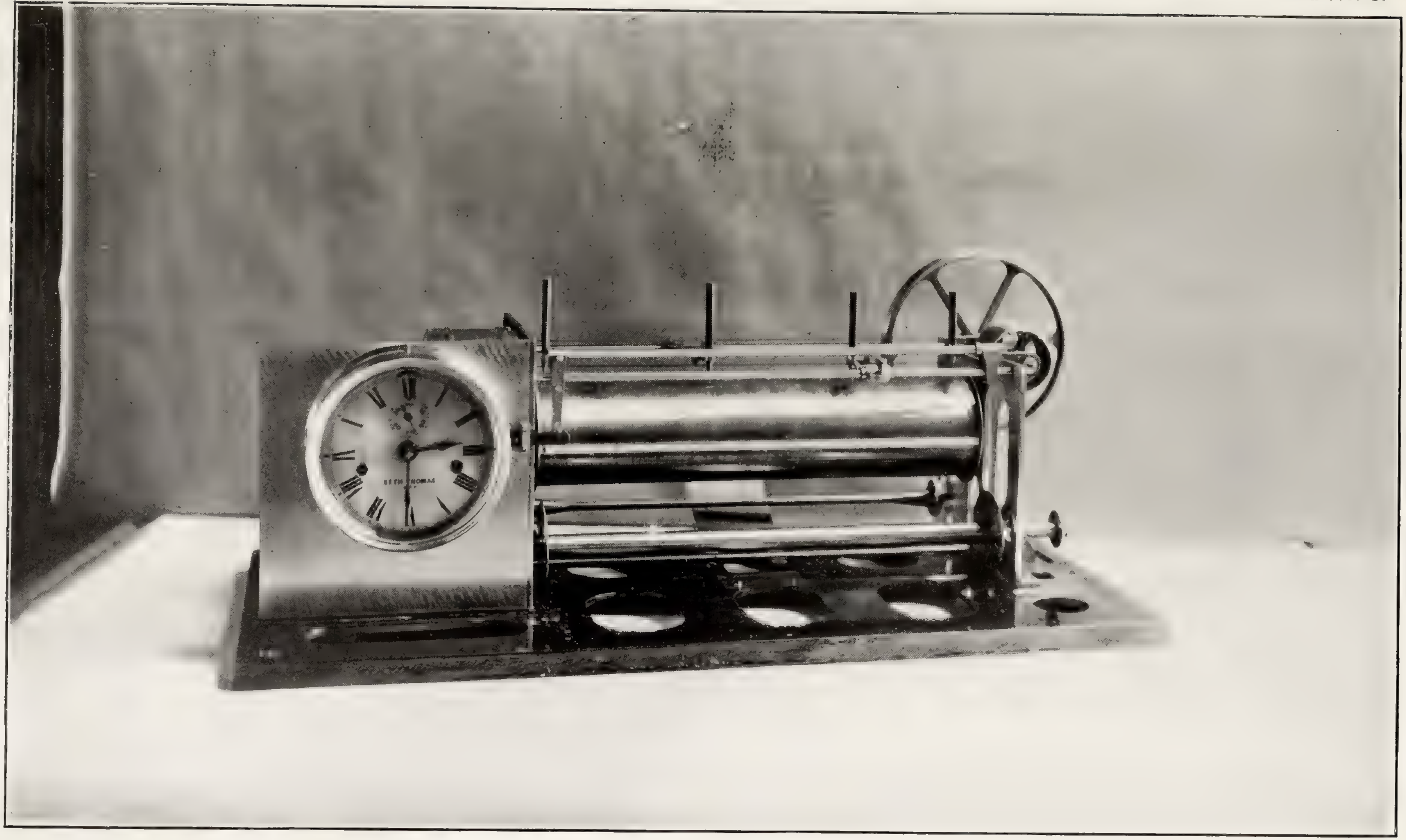
PLATE No. 3

CATAMARAN without house in use on Niagara River.



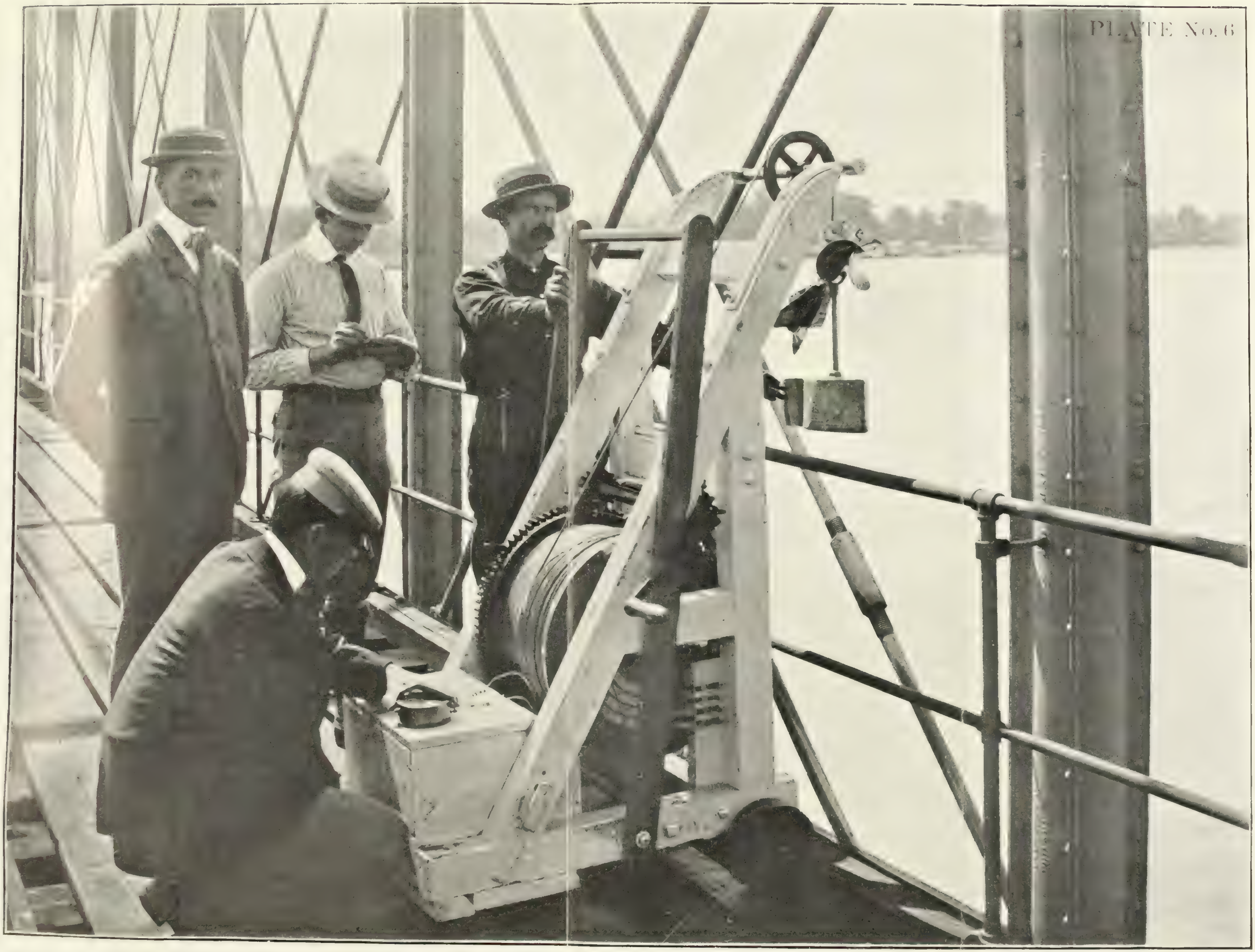
UNITED STATES LAKE SURVEY SELF-REGISTERING WATER GAUGE.

PLATE No. 5.



UNITED STATES LAKE SURVEY SELF-REGISTERING WATER GAUGE.

PLATE No. 6



REEL FOR CURRENT OBSERVATIONS, INTERNATIONAL BRIDGE, BUFFALO.

The resulting large increase in the number of discharge measurements created a demand for more coefficient work and more soundings to determine cross-sectional area in order to maintain a proper proportion in the distribution of the observations.

In each of these operations new methods were employed. In sounding a static method was introduced, in which the curvature of the sounding wire under current pressures is susceptible of analysis and proper corrections applied.

In coefficient work, which aims at the establishment of the ratio between the velocity at the discharge point of a station and the mean velocity throughout the station area, the use of 2 meters as a compound instrument was begun and developed into a powerful method.

As part of this system daily ratings of the B meter were made in the current, side by side with the A meter, to note for each day's work the comparative running values of the wheels of the 2 instruments so that the rating of one instrument depended on the other, making of the two a unit or compound meter.

Plans for this sounding and coefficient work were matured while the ice was running, through the latter part of December, 1899, and during the following January. By the early part of February the head of the river had frozen over and running lake ice was shut off. Soundings were then made and coefficient work pursued until the ice again interfered in April, and after it had ceased running in mid-May work was again resumed and continued until July 1.

Some discharge observations were made during the winter season to ascertain the effect of the sealing of the head of the river on the volume of discharge.

In January, 1899, automatic gauge No. 8 was installed in the slip at the foot of Austin street to record (with a small slope correction) the elevation of the water surface at the bridge and, in connection with automatic gauge No. 7, to establish slope relations.

This latter gauge was established through the courtesy of the Light-House Board in the boiler room of the Breakwater Light at the entrance to Buffalo Harbor. It is designed to give Lake Erie level. It was installed in February and a trial record was made during part of that month. Its permanent record began March 1 and continued until the middle of August, when it was replaced by gauge No. 11, of the same type, but having ball bearings. Gauge No. 8 was at the same time replaced by Gauge No. 12.

In the intervals between gauge installations and observations some office work was accomplished toward reducing field notes, summarizing data, and taking out preliminary values for the discharge volume. Gauge sheets were worked up as they were taken from the gauges.

Coefficient observations on the bridge section were followed by meter ratings on a still-water base July 9 and 10, 1899, and these gave way to active preparations for a check measurement of the flow of the river on a section near the foot of Squaw Island, about 1,800 feet below the International Bridge.

A base across the bridge was measured as an initial line in a system of triangulation. Stations were established for transit intersection work, and a series of floats, started at different point on the bridge, were traced with two transits, and the resulting current lines platted on a large-scale map.

From these the azimuth of the open section was established so as to be normal to the mean direction of flow.

A system of intersecting ranges was set up on Squaw Island to locate meter stations from the survey boat.

Small timber cribs were put in at the section ends to support long-range gauges. These were set in about 4 feet of water on each shore, being 1,720 feet apart.

These preparations were preliminary to the use of the fleet for open-river work, which arrived August 11 from Detroit, in charge of Capt. Charles L. Wilson. This consisted of the steam tug *General G. K. Warren*, a steel catamaran, and a skiff.

As soon as the catamaran, which had been taken apart for her lake trip, was assembled and made ready for work, soundings were made in the river in the vicinity of the open section for the double purpose of finding the best methods of manipulating the catamaran in the strong current and to secure data concerning the river bottom above and below the working section.

Soundings in detail on the section for area of waterway were then made, and late in August discharge measurements were begun, using a single meter, L. S. 2 B.

These observations were continued for about a month.

The meters were then taken to the Prospect Reservoir and rated.

Arrangements had meanwhile matured for observing with two meters, and river work was resumed early in October.

Instead of dropping the meter through the opening of the deck toward the stern of the catamaran, as had been done up to this time, the two meters now entered the water abreast and about 2½ feet forward of the deck.

From this time on the system of work was used that characterized the open section.

The compound meter used in coefficient work on the bridge section was used here in discharge observations also.

Observations for discharge were continued until December 15, fifty-seven measurements with the compound meter being made.

Coefficient work and soundings were also carried on during this time, and the meters were again rated at the reservoir in the middle of November.

A subsequent rating of the instruments was made through the ice on the same base in February, 1900.

After the laying up of the fleet, office work began late in December, 1899.

The reduction of the field notes and interpretation of the observations kept the office force fully employed until late in June, 1900.

During this time a complete reduction of the open-section discharge was computed; new coefficients were derived for the bridge section and the discharges recomputed; gauge records were secured and worked up, getting out daily and monthly means for lake and section elevations.

Fitting out for the season's work for the summer of 1900 was begun June 18. Discharge measurements for the annual crest of high water were begun late in June on the open section after rating instruments on the base.

This is a naked narrative of operations thus far; but as the reliability of results is dependent on the detail of method and instrument, and as the interest which attaches to a piece of hydraulic work lies not alone in the number of cubic feet, but in the processes of measurement and of computation, and in citations of observations, these are gone into somewhat in the balance of this report.

The Niagara River, as it breaks out of Lake Erie, flows almost due north. It narrows rapidly and passes swiftly through a choked section of limestone, where the speed at mid-river must approximate 8 miles an hour. Emerging from this, the river grows wider and deeper and slows up to about 5 miles an hour as it approaches the International Railway Bridge, 12,000 feet below the head of the river.

In this distance the fall is about 5 feet at mean lake stage.

The bridge consists of nine spans on masonry piers carrying a single-track railway. Enough clearance exists between the track and the through trusses for footways on each side, which are, however, cramped and not open to public travel. The base of rail is about 24 feet above the water surface. The piers rest in timber caissons and are provided with cutwaters. Protective masses of large stone are dumped about the piers, making a somewhat ragged profile and a bottom dangerous to instruments.

The piers have a small battir, but may be considered vertical for river-gauging purposes.

The length in feet of clear waterway and the maximum depth of the several spans are as follows:

Number of span.	Length.	Maximum depth.	Percentage of discharge passing each span.
1	151.5	13.1	0.5
2	154.1	13.8	2.5
3	156.2	35.7	9.7
4	234.2	48.3	28.2
5	235.8	47.3	26.7
6	235.3	50.7	18.2
7	187.0	26.6	8.6
8	184.3	17.1	5.5
9	138.4	9.6	0.7

The numbering of the spans as used in the gauging begins on the east end, the drawbridge spanning the second and third openings, the ship channel passing through the third.

The long spans, 4, 5, and 6, naturally divide up into three station lengths of about the same size as the half-span lengths in which the remaining openings are conceived as divided. This cuts up the clear waterway of the river into 21 station areas, each about 80 feet long. Each of these is divided again into four substations of about 20 feet. Midway of each station area, and at approximately three-tenths depth, a point is taken as representative of the velocities throughout the area. Because it indicates the station discharge it has been called the index.

The measurement of the discharge consisted in obtaining the velocities at each of the 21 station indexes in quick succession. Coefficient work then established the ratio between the mean velocity in the station area and the observed index velocity. With cross-sectional area determined by the soundings, the station discharge = coeffi-

cient × index velocity × cross-sectional area; and the full-river discharge is a summation for all stations of these partial discharges.

In the open section below the bridge the 1,720 feet between the terminal cribs was divided into 16 stations of 100 feet and 1 of 120 feet; and the indexes were taken at mid-station at approximately four-tenths depth.

Reconnaissance soundings from the bridge were taken by the Board of Engineers on which index depths were founded, and the station scheme as used by them was followed in the Lake Survey work on this section.

The Lake Survey soundings were subsequent to considerable meter work, but as logically soundings should precede this they will be taken up here.

A current of 5 miles an hour with a depth of nearly 50 feet in the fourth and fifth spans of the bridge rendered ordinary methods of sounding inaccurate. Even as heavy a lead as 40 pounds on a sash cord thrown upstream and quickly dropped to bottom gave results that are indeterminate in two partictulars. First, the observer is unable to say whether the lead is on bottom above, below, or in the plane of the section; second, with the lead touching bottom and dragging a belly is created in the sounding line by the current pressures on it of unknown form, and the indicated depth is too great by an unknown amount. An error of 2 to 3 feet in 50 may readily enter in a 5-mile current from these causes.

A percentage error in the soundings of a station produces the same percentage error in the volume of discharge of that station, since mean depth × width × mean velocity = discharge.

Moreover, it is in the important stations where, with highest speed and greatest depth, the discharge is largest that this percentage error is most likely to occur; and it is in these stations that accurate sounding is most imperative by reason of their weight in the aggregate volume of flow.

Any refinement in the other factors that enter into the problem of river gauging is annulled by less refinement in the sounding.

Out of this demand for just as good work in outlining the bottom profile as in velocity measurement was evolved the static method of sounding.

It depends on the elementary principle of mechanics, that when a known horizontal force is applied to a weight suspended on a cord the cord takes a position of rest at some angle, a, with the vertical.

If the vertical distance from the point of suspension to the weight be taken as unity, while P is the horizontal pressure and W the vertical force due to the weight,

$$\frac{P}{W} = \text{tangent } a \quad \ldots\ldots\ldots\ldots \quad (1)$$

Or, if in addition a number of horizontal forces

$$\begin{array}{l} p_{10}, p_9, p_8, \quad \cdots \quad p_0 \\ u_{10}, u_9, u_8, \quad \cdots \quad u_0 \end{array}$$

and a number of upward vertical forces be applied along the cord, the angle of the line above all points of application is found from

$$\frac{P + \Sigma p}{W - \Sigma u} = \text{tangent } a_0 \quad \ldots\ldots\ldots\ldots \quad (2)$$

Equation (2) expresses the conditions in sounding in running water, P being the downstream current pressure on the weight, p_{10}, p_9, p_8, etc., being the pressure on unit vertical lengths of the sounding wire at different depth, W being the downward gravity force of the submerged weight, and u_{10}, u_9, u_8, etc., representing the uplifting force of the current on unit depth lengths at different depths of the slanting wire.

It was found that with a properly designed sounding weight in the comparatively dead water near the bottom, P could safely be neglected; and that with a heavy weight and a very light wire the uplift of the current in ordinary work was small, and could be applied as a correction to tabulated values derived from the simple equation

$$\frac{\Sigma p}{W} = \text{tang } a_0 \quad \ldots\ldots\ldots\ldots \quad (3)$$

W being known, and the angle a_0 being measured at the water surface, the total current pressure P may be derived.

It remains to distribute this known total current pressure along the sounding wire so that p_{10}, p_9, p_8, etc., may have proper percentages of it.

The variation of velocities from surface to bottom is so nearly the same at different stations and at different depths that a vertical curve may be platted that is typical. Its exact form is not essential to the validity of the results that enter into any of the soundings on which the discharge of the Niagara River depends, and no great error would result from the assumption that velocities were uniform from top to bottom.

However, a typical vertical curve was chosen and velocities taken off for each tenth of depth. These were squared, summed up, and each divided by the sum, thus deriving the percentage pressures, when Σp is unity.

The squaring of the velocities is in accordance with the well-established hydraulic principle that pressures vary as the square of the velocities that produce them.

The curve traced by the wire as it hangs just before the weight touches the bottom may now be platted.

Beginning at the bottom the inclination of the wire for the first tenth of depth is gotten from the tang $a_{10}=\frac{p_{10}}{W}$; the inclination of the second tenth is derived from

$$\text{tang } a_9=\frac{p_{10}+p_9}{W};$$

the angle for the third tenth from

$$\text{tang } a_8=\frac{p_{10}+p_9+p_8}{W}; \text{ etc.}$$

With known angles for each tenth of depth the amount by which the curved wire is greater than the depth is the sum of the external secants of these angles, the total depth being 10.

For any other depth the correction is proportional.

Proceeding in this way computations were made for all even degrees of surface angle, and a table of corrections prepared. This table was corrected for the uplift of the current and is made a part of this report. (Table No. 1.)

TABLE No. 1.—*Static sounding.—Table of corrections.*

Depth.	Inclination of sounding line to vertical at water surface.																	
	2°.	4°.	6°.	8°.	10°.	12°.	14°.	16°.	18°.	20°.	22°.	24°.	26°.	28°.	60°.	32°.	34°.	36°.
Ft.																		
10	0.00	0.01	0.02	0.03	0.05	0.07	0.10	0.13	0.16	0.20	0.25	0.30	0.35	0.41	0.47	0.54	0.62	0.70
12	0.00	0.01	0.02	0.04	0.06	0.09	0.12	0.15	0.20	0.24	0.30	0.36	0.42	0.49	0.57	0.65	0.74	0.81
14	0.00	0.01	0.02	0.04	0.07	0.10	0.14	0.18	0.23	0.29	0.35	0.41	0.49	0.57	0.66	0.76	0.87	0.98
16	0.00	0.01	0.03	0.05	0.08	0.12	0.16	0.20	0.26	0.33	0.40	0.47	0.56	0.65	0.76	0.87	0.99	1.12
18	0.00	0.01	0.03	0.06	0.09	0.13	0.18	0.23	0.30	0.37	0.45	0.53	0.63	0.73	0.85	0.98	1.12	1.26
20	0.00	0.01	0.03	0.06	0.10	0.14	0.20	0.26	0.33	0.41	0.50	0.59	0.70	0.82	0.94	1.09	1.24	1.40
22	0.00	0.01	0.04	0.07	0.11	0.16	0.22	0.28	0.36	0.45	0.55	0.65	0.77	0.90	1.04	1.20	1.36	1.54
24	0.00	0.01	0.04	0.08	0.12	0.17	0.24	0.31	0.39	0.49	0.60	0.71	0.84	0.98	1.13	1.31	1.49	1.68
26	0.00	0.02	0.04	0.08	0.13	0.19	0.25	0.33	0.43	0.53	0.64	0.77	0.91	1.06	1.23	1.41	1.61	1.81
28	0.00	0.02	0.04	0.09	0.14	0.20	0.27	0.36	0.46	0.57	0.69	0.83	0.98	1.14	1.32	1.52	1.74	1.95
30	0.00	0.02	0.05	0.10	0.15	0.22	0.29	0.38	0.49	0.61	0.74	0.89	1.05	1.22	1.42	1.63	1.86	2.09
32	0.00	0.02	0.05	0.10	0.16	0.23	0.31	0.41	0.52	0.65	0.79	0.95	1.12	1.31	1.51	1.74	1.98	2.23
34	0.00	0.02	0.05	0.11	0.17	0.24	0.33	0.44	0.56	0.69	0.84	1.01	1.19	1.39	1.60	1.85	2.11	2.37
36	0.00	0.02	0.06	0.12	0.18	0.26	0.35	0.46	0.59	0.73	0.89	1.07	1.26	1.47	1.70	1.96	2.23	2.51
38	0.00	0.02	0.06	0.12	0.19	0.27	0.37	0.49	0.62	0.78	0.94	1.12	1.33	1.55	1.79	2.07	2.36	2.65
40	0.00	0.02	0.06	0.13	0.20	0.29	0.39	0.51	0.66	0.82	0.99	1.18	1.40	1.63	1.89	2.18	2.48	2.79
42	0.00	0.03	0.07	0.13	0.21	0.30	0.41	0.54	0.69	0.86	1.04	1.24	1.47	1.71	1.98	2.28	2.60	2.93
44	0.00	0.03	0.07	0.14	0.22	0.32	0.43	0.56	0.72	0.90	1.09	1.30	1.54	1.80	2.08	2.39	2.73	3.07
46	0.00	0.03	0.07	0.15	0.23	0.33	0.45	0.59	0.75	0.94	1.14	1.36	1.61	1.88	2.17	2.50	2.85	3.21
48	0.00	0.03	0.08	0.15	0.24	0.35	0.47	0.61	0.79	0.98	1.19	1.42	1.68	1.96	2.27	2.61	2.98	3.35
50	0.01	0.03	0.08	0.16	0.25	0.36	0.49	0.64	0.82	1.02	1.24	1.48	1.75	2.04	2.36	2.72	3.10	3.49
52	0.01	0.03	0.08	0.17	0.26	0.37	0.51	0.67	0.85	1.06	1.29	1.54	1.82	2.12	2.45	2.83	3.22	3.63
54	0.01	0.03	0.09	0.17	0.27	0.39	0.53	0.69	0.89	1.10	1.34	1.60	1.89	2.20	2.55	2.94	3.35	3.77
56	0.01	0.03	0.09	0.18	0.28	0.40	0.55	0.72	0.92	1.14	1.39	1.66	1.96	2.28	2.64	3.05	3.47	3.91
58	0.01	0.03	0.09	0.19	0.29	0.42	0.57	0.74	0.95	1.18	1.44	1.72	2·03	2.37	2.74	3.16	3.60	4.05
60	0.01	0.04	0.10	0.19	0.30	0.43	0.59	0.77	0.98	1.22	1.49	1.78	2.10	2.45	2.83	3.26	3.72	4.19
62	0.01	0.04	0.10	0.20	0.31	0.45	0.61	0.79	1.02	1.26	1.54	1.84	2.17	2.53	2.93	3.37	3.84	4.33
64	0.01	0.04	0.10	0.20	0.32	9.46	0.63	0.82	1.05	1.31	1.59	1.89	2.24	2.61	3.02	3.48	3.97	4.47
66	0.01	0.04	0.11	0.21	0.33	0.48	0.65	0.84	1.08	1.35	1.64	1.95	2.31	2.69	3.12	3.59	4.09	4.61
68	0.01	0.04	0.11	0.22	0.34	0.49	0.67	0.87	1.12	1.39	1.69	2.01	2.38	2.77	3.21	3.70	4.22	4.75
70	0.01	0.04	0.11	0.22	0.35	0.50	0.69	0.90	1.15	1.43	1.74	2.07	2.45	2.86	3.30	3.81	4.34	4.89
72	0.01	0.04	0.12	0.23	0.36	0.52	0.71	0.92	1.18	1.47	1.79	2.13	2.52	2.94	3.40	3.92	4.46	5.03
74	0.02	0.04	0.12	0.24	0.37	0.53	0.73	0.95	1.21	1.51	1.84	2.19	2.59	3.02	3.49	4.03	4.59	5.17
76	0.02	0.05	0.12	0.24	0.38	0.55	0.74	0.97	1.25	1.55	1.88	2.25	2.66	3.10	3.59	4.13	4.71	5.30
78	0.02	0.05	0.12	0.25	0.39	0.56	0.76	1.00	1.28	1.59	1.93	2.31	2.73	3.18	3.68	4.24	4.84	5.44
80	0.02	0.05	0.13	0.25	0.40	0.58	0.78	1.02	1.31	1.63	1.98	2.37	2.80	3.26	3.78	4.35	4.96	5.58
82	0.02	0.05	0.13	0.26	0.41	0.59	0.80	1.05	1.34	1.67	2.03	2.43	2.87	3.35	3.87	4.46	5.08	5.72
84	0.02	0.05	0.13	0.27	0.42	0.60	0.82	1.08	1.38	1.71	2.08	2.49	2.94	3.43	3.96	4.57	5.21	5.86
86	0.02	0.05	0.14	0.28	0.43	0.62	0.84	1.10	1.41	1.75	2.13	2.55	3.01	3.51	4.06	4.68	5.33	6.00
88	0.02	0.05	0.14	0.28	0.44	0.63	0.86	1.13	1.44	1.80	2.18	2.60	3.08	3.59	4.15	4.79	5.46	6,14
90	0.02	0.05	0.14	0.29	0.45	0.65	0.88	1.15	1.48	1.84	2.23	2.66	3.15	3.67	4.25	4.90	5.58	6.28
92	0.02	0.06	0.15	0.29	0.46	0.66	0.90	1.18	1.51	1.88	2.28	2.72	3.22	3.75	4.34	5.00	5.70	6.42
94	0.02	0.06	0.15	0.30	0.47	0.68	0.92	1.20	1.54	1.92	2.33	2.78	3.29	3.84	4.44	5.11	5.83	6.56
96	0.02	0.06	0.15	0.31	0.48	0.69	0.94	1.23	1.57	1.96	2.38	2.84	3.36	3.92	4.53	5.22	5.95	6.70
98	0.02	0.06	0.16	0.31	0.49	0.71	0.96	1.25	1.61	2.00	2.43	2.90	3.43	4.00	4.63	5.33	6.08	6.84
100	0.02	0.06	0.16	0.32	0.50	0.72	0.98	1.28	1.64	2.04	2.48	2.96	3.50	4.08	4.72	5.44	6.20	6.98

NOTE.—This table gives the amount by which the indicated depth is to be reduced to get actual depth. Use nearest tenth of a foot for correction; hundredths are given for interpolation only.

The table is general, not for any particular wire nor for any particular sounding weight, provided it is designed so as to present little current resistance.

Proper design in weight and wire must take into account the fact that the wire alone takes almost all the current pressure, and that this will vary as the diameter of the wire, while the strength of the wire varies as the square of the diameter. This points to as heavy a weight as is practicable for swift, deep water and as small a steel wire as will carry it with only reasonable safety. The weight used on the bridge and open sections was of cast iron, weighing about 140 pounds. The probability of fouling and losing the weight precluded the use of the more expensive lead even if it had been desirable. Its greater compactness for handling above water is the principal reason why lead might be used.

The shape of the weight was a 9-inch sphere drawn out to a sharp nose at one end to split the current, and drawn out and slotted at the rear to receive a tail. An attachment ring was sat rigidly at a point above the center of gravity on the back.

The belly had all the advantages of a sphere in clean contact with the river bottom. The 18-inch shingle tail, wedged in the rear slot, held the nose to the current so that the weight presented little resistance to the flow, and prevented twisting of the wire, which would endanger breaking it.

The name "Polliwog," which my boys christened this weight, was expressive of its general appearance. After losing this, the second became the "Tadpole;" and a 600-pound weight used in sounding the Niagara Gorge by logical growth became the "Bullfrog."

In soundings from the International Bridge, a wire strand about an eighth of an inch in diameter was used; in the open-section work No. 12 galvanized iron wire, and at the Niagara Gorge plow-steel wire of the highest grade, one-tenth of an inch in diameter, suspended the 600-pound "Bullfrog."

This last sounding was made to test the method and to get the depth of the river at the crossing of the Cantilever Bridge, as a matter of scientific interest.

Here the river has just entered the gorge and is speeding along at a rate of at least 10 miles an hour, with a depth of nearly 70 feet.

The work was done in conjunction with Mr. W. C. Duncan, assistant bridge engineer of the Michigan Central Railway, to whom the matter was of interest in connection with the bridge abutments.

A full set of soundings were successfully made from the bridge, 240 feet above the water, developing the cross section.

To get these results cost four of these great weights, which were furnished by the railroad company.

At extreme depth in mid river the angle at the water surface was 36 degrees, and marks the limit which is permissible. For conditions more difficult than these a heavier weight would be required.

The 140-pound weight here rested on the surface of the stream like a cork.

This is a remarkable piece of work in sounding and indicates the possibilities of the static method.

In all these soundings the bridge reel was used in which a drum 5 feet in circumference tells off the length of wire.

The drum was carefully built up and tested so that the zero and 50-foot beads met after ten returns of the wire.

The drum is graduated to tenths of a foot.

On the bridge section guys were necessary to make the weight enter the water upstream far enough so that the inclination of the wire would bring it fair in the plane of the section. Four sets of soundings were taken in the principal spans; one on the true section, two below the section, and one from the south side of the bridge above the section, thus developing the bottom profile a short distance up and down stream. This is sometimes necessary in order to explain the trend of the vertical velocity curves, as in the seventh span, where the bottom slopes abruptly downstream, creating a dead-water area.

The maximum angle in 47 feet of water in the fourth span was 15 degrees, which indicated a correction for the submerged portion of the wire of 0.5 foot. An additional correction was applied for the slant of the wire above water.

Along the section soundings were taken about every 10 feet, and near the piers and where the profile was irregular the bottom was carefully developed by additional soundings.

In the open section soundings were taken every 10 feet from the survey catamaran, using the "Tadpole" 140-pound weight.

The 10-foot intervals were cut off by a transit set on the front range post.

The soundings were made twice over, to insure safe results.

Reconnaissance soundings were made preliminary to work on the open section on

squares of a hundred feet, covering a thousand feet of the river length in the vicinity of the section. No curvature corrections were applied to these.

The same current pressures that tend to swing the sounding weight downstream, operate with greater effect on the larger cables of the meters. The vertical angles were reduced as much as practicable by the 136-pound leads of the instruments, but on the bridge section guys were necessary on vertical curve work to keep the meter in its proper plane, and a table of corrections was constantly used in coefficient work on the bridge and in all work in the open section, to place the meter at its proper elevation.

The analysis of meter positions was first made by Mr. C. B. Stewart in discussing the deep waterways observations on this river; and out of this germ has been developed our own tables for meter location and the static method of sounding.

The wetted perimeter of the bridge section as developed by the soundings is so broken and irregular, and the water is so perturbed and deflected by the bridge piers and by a caisson that escaped during construction and lies across a portion of span 6, that the validity of results derived from such a section may be questioned.

A discussion of this point, however, points to an error to be expected from this source but little in excess of that of an open-river section.

Let it be assumed that the eddies and boilings close to the piers make correct estimates of the flow impossible in areas extending for certain distances from them, and that the caisson lying across a portion of span 6 adds another uncertain area.

The resulting indetermination as affecting the total volume of flow may be closely estimated as follows:

Taking the doubtful regions as those portions of the cross-sectional area extending 10 feet in spans 1, 2, 8, and 9, and 20 feet from the piers in the remaining spans; adding 300 square feet for the caisson, they are as follows:

	Square feet.		Square feet.
Span 1	90	Span 7	440
2	110	8	340
3	500	9	200
4	680		
5	960	Total	4,260
6	940		

This is about 10 per cent of the total cross section. With a velocity taken as half that of the mean velocity of the river the discharge in question is 5 per cent of the total volume.

It is not probable that the errors in estimating the flow in these 19 doubtful places will all have the same sign. In some the quantity will be taken too great and in some too small, so that the summation will balance error against error and eliminate a part of them. It will, therefore, be entirely safe to assign 10 per cent as a maximum error in the sum of the partial discharges.

With this liberal allowance the indetermination in the volume of flow of the full river, from this cause, is seen to be 10 per cent of 5 per cent, which is but one-half of 1 per cent.

In view of the small cost of gauging from a bridge as compared with open-river work the bridge section warrants the large excess of coefficient work necessary to place its results in comparison with those of a simpler section with unbroken flow.

Regarding the final results, the checking of the volume of the discharge is the more reliable because the two sections present conditions so different as to require independent methods of treatment for the determination of coefficients.

Before taking up the use of the meters in discharge and coefficient work it will be well to describe the instruments and the methods of calibrating them.

The two meters used by the Lake Survey on this river were designed by Mr. E. E. Haskell.

The first received and used in the discharges measured on the bridge section in the fall and early winter of 1898 bears the inscription L. S., 2 B., Ritchie, Boston.

The instrument proper consists of a brass propeller wheel of four blades, spinning on a steel pivot. The general shape of the meter is shown by the accompanying illustrations. The steel pivot shaft enters the hub and extends to the nose of the wheel where the female bearing is located. The wheel turns on this pivot as a thimble spins on a pin.

The body of the meter has the pivot shaft inserted in its forward end, and at the other end is attached a tail of brass tubing carrying four vanes of sheet brass. The body passes horizontally through a ring on its standard, to which it is secured by

lateral pivot screws, which gives some play in the vertical plane. The tail has an air chamber by which the instrument is adjusted so that it balances on these pivots when submerged. A brass rod leads upward from the ring and is attached to it by a ball-bearing swivel joint. This rod is attached at its upper end to a clevis connected with the steel cable by which the meter is suspended. Below the ring another brass rod carries the lead weight which holds the instrument down in the current and maintains the erect position of the standard rods. The standard lead of the B meter, which was used during 1898, weighs 42 pounds. In February, 1899, the 136-pound lead was put on and used in all subsequent observations.

By means of the ball-bearing joint and the pivoted body connection the tail or rudder makes the meter take the direction of the current and presents the wheel true to its thread.

As the wheel spins by the impulse of the current, a ring in its rear end, which is half of platinum and half of hard rubber, presents each alternately to a platinum-pointed pin, which is held gently against the ring by a spiral brass spring. When the platinum part of the ring is in touch with the pin an electric circuit is established, which is broken as the revolution of the wheel brings the rubber-insulated half in contact.

The electric current is supplied by voltaic cells above water.

The battery for each meter, as used most of the time, consisted of four small cells, two Sampson, and two Edison-Lalande, Type X, connected in series. Later the eight jars were used as a unit.

This current is carried to the meter by an insulated copper wire that forms the core of the ¼-inch plow-steel wire cable used to lower and raise the meter and to take the return current. A register is in the circuit in which an armature actuates an escapement, permitting a spring-driven train of wheels to advance at each make and break of the current. The wheels carry indexes which count off the turns of the meter wheel. The meter wheel turns once for each 1.4 feet of current thread, approximately.

Each register is equipped with a stop watch. When this is not running the electric circuit is broken. Pressing the stem of the watch starts it and at the same instant establishes the circuit, so that registration and time measurement start together.

Meter L. S., 2 B, measures 27 inches from nose to end of tail.

The wheel is 4½ inches long and 7⅝ inches at greatest diameter.

With its standard lead the meter weighs 49 pounds, while with its heavy lead it weighs 143 pounds.

The axis of the meter is 16 inches above the bottom of the lead; and this is the nearest to the river bottom that the wheel can measure velocities.

The second instrument, L. S. 4 A, is known as a direction-current meter, because it records not only the speed of the current but its azimuth as well.

The current-measuring principle and the detail are much the same as in the B meter, except that the body is swelled to encase the mechanism dealing with direction. This consists of a magnetic needle sealed in a brass cylinder that is pivoted on pin points and is suspended in kerosene which fills the case. By releasing stops above water this needle assumes its magnetic position. An armature is also encased which actuates a mechanism that carries a hand from its position of rest in the direction of the axis of the instrument, until it comes into contact with the magnetic needle, where it stops, because the circuit is then broken.

Releasing stops allows the hand to again assume its position of rest, so that the observation may be repeated.

Two additional insulated wires carried in the ⅜-inch steel cable furnish an electric circuit to the direction part of the meter.

In the observer's hands in this circuit is an indicator operated by an armature. A clockwork mechanism when set in motion makes and breaks the current. This moves the armatures, both in the meter and in the indicator, so that the angle traveled by the encased hand in reaching the north is reflected by a hand in the indicator.

The advantage of this in tidal currents is very obvious. In this river its use was not necessary in direction work, as less intricate methods of noting the very well-defined current lines sufficed.

The length of the A meter from nose of wheel to end of tail is 39¾ inches.

Its weight with standard lead is 81 pounds; with heavy lead about 163 pounds.

Its wheel is similar to that of the B meter.

The A meter in particular is very reliable in holding its rating during a long season and showing small daily variations.

The B meter is credited with a somewhat greater range in its diurnal fluctuations, but has a remarkable record for the pertinacity with which it clings to a mean rating.

The original calibration of this instrument was in September, 1898.

In February, 1900, an elaborate rating gave a value to the mean wheel revolution but 1 per cent different from its original rating.

In the interim the meter had suffered the vicissitudes of gauging a wicked section; it had been fouled on a ragged bottom and caught in the sheet-iron sheathing of a bridge pier; had bent the blades of its wheel and had them retrued; it had lost its tail and had it replaced by a somewhat different one; its standard lead had been changed for one three times as heavy; its pivot had been dulled by passing upward of 5,000 miles of current thread through the wheel.

The strength of the instrument may be judged by this test; its sentiveness may be gathered from its rating observations.

These are necessary in order to interpret the registered revolutions as the meter spins in the stream into length of water thread, and thus obtain the speed of the current in feet per second.

They consisted in moving the meter through a measured length of still water, noting the time occupied in traversing this rating base and the corresponding revolutions of the wheel.

This method of calibration rests on the theory that moving water will produce the same number of wheel revolutions per second on a stationary meter as stationary water will cause on a moving meter; in short, that it is simply a case of relative motion between the meter and the water; and when this relative velocity exists the registration is independent of the motion of either water or meter with respect to the earth.

The still-water base used by me in Buffalo for rating was at the Jefferson equalizing reservoir of the city water supply system.

This reservoir consisted of two basins connected by a 36-inch pipe; each basin is connected with the water mains by a 36-inch pipe. The basins are nearly of the same size, the east one used being 465 by 673 feet.

With Niagara River water 40 feet deep, the absence of any considerable current, paved slopes, and closely cut turf margins well adapted for the sprinting of the men forming the teams, the conditions were excellent for good work.

The lake survey is indebted to the superintendent of waterworks and to Mr. Louis H. Knapp, Mem. Am. Soc. C. E., the hydraulic engineer in charge, for the privilege of using this reservoir.

Across this basin a piece of telegraph wire was stretched and drawn so taut that, while the ends were about 4 feet above the water the middle cleared the surface by about a foot. On this wire, soldered 200 feet apart, were two brass beads, whose dual office was, first, to mark the base length, and second, to operate levers as the meters passed to start and stop the watches that measured the time, and the registers that noted the revolutions of the wheel.

The 200 feet so indicated constituted the rating base.

Two hardwood tubes were strung on the wire so that they could run freely from shore to shore, and attached at bow and stern guide a skiff carrying the meters.

A continuous manila line, five-sixteenths inch in diameter, was stretched across the reservoir, running along the base wire to the north bank, then along that bank to the northeast corner, southward along the east bank, and returning to the south end of the base wire. It thus formed a quadrangle, one of whose sides was along the base wire, while the parallel side occupied the east bank, where a running course was laid off. Pulleys at the four corners made this whole line movable.

The guide tubes were fastened to this, so that the boat formed a link in an endless chain.

When the towing team took hold of the line and moved along the running course on the east bank the boat was drawn across the reservoir, along its trolley wire, in the opposite direction and at the same speed.

By suitable hook fastenings the skiff was readily turned so as to travel bow on in either direction. Running first north, then back again south at the same speed, a pair of readings was obtained that were treated as a single observation for rating. In this full observation any small current parallel to the base is eliminated by appearing as a positive quantity in one and a negative in the other.

By taking many such pairs, at such velocities as were encountered in the river, data were secured from which the relation between the revolutions of the wheel and the velocity of the actuating current was computed.

In speeding the meters on the rating base, the two were rated simultaneously. This economized time; treated the two as a compound instrument, as was done on the river, and yielded an excellent criterion by which to reject abnormal observa-

tions. It served also as a check on the accuracy of the work, indicating whether any deviation of the resulting rating line from previous lines was due to some variation in the instrument itself, or to some variation in the conditions of rating as a cross current, motion of the boat from wind and waves, or irregular towing.

If the disturbance was internal it should be present in but the meter concerned; if, on the contrary, it was due to the conditions of rating, it should be reflected in both instruments.

Simultaneous fluctuations in the number of revolutions indicate wholesome observations.

A boom of white pine, 4 by 4 inches square and 10 feet long, was put crosswise of the skiff 5 feet back from the bow and bolted to a board that was lashed to the gunwale. From the extremities of this outrigger the meters were suspended by special rating cables. These were short pieces cut from the long cables used in the river, with precisely the same meter attachments. The axes of the instruments were about 4.5 feet below the surface. The observer sat on the stern seat with the two registers attached to the automatic cut-off on a rough desk before him. The electric batteries operating the registers were carried well to the stern to help balance the weight of the meters forward.

As the A meter weighs with its heavy lead over 160 pounds, and the B meter over 140 pounds, it was necessary to build a dock with hoists, for safe handling of the instruments; and with supports to prevent the light skiff from careening when but one outrigger was loaded.

The running course along the west bank was divided by tags of cotton cloth into 25-foot lengths, and the team moved over each of these parts in equal time intervals, by passing each as a timekeeper called "tick." This method of graduation was used by Mr. C. B. Stewart in rating meters for the deep waterways measurement of Niagara River.

It proved a convenient method of carrying out a rating programme so as to secure a well-graded range of velocities.

The towing was done by four men, and in the higher velocities all were needed on the line. In the low velocities they worked on alternate runs and rests in teams of two, making the trips consecutive, without loss of time for breathing.

Handspikes were attached to the line, so that the men walked or ran abreast pushing on these.

When the observer in the boat signaled "ready" the team started at a uniform pace, maintaining this for 50 feet, before the initial base line bead was reached, and well past the terminal bead.

The observer in the stern of the boat, noted the readings of his registers, and set the hands of the stop watches at zero before signaling; then as the instruments moved over the course he listened to the click of the armatures to insure perfect registration, and kept the bass wire true in the grooved wheel of the automatic cut-off. As the cut-off passed the zero of the 200-foot base the initial bead coming in contact with levers, spread them, which pressed rubber fingers against the stems of the two stop watches, starting them and at the same time completing the electric circuit through the meters, which registered the revolutions of the wheels. On passing the terminal bead a second pressure stopped the watches and the registration. The observer noted the time in transit and the registration and again set the watches at zero; then turned the skiff and made the return run in the same way.

In this manner a systematic programme of observations was carried out, constituting a rating of each instrument.

The programme aimed to secure a range of velocities corresponding with those of the river, and with a mean velocity approximately the same; and to secure them in such order as to introduce no other element than change of velocity.

The rating conditions are constantly changing, and while the effect of these conditions on the result are minute, still it was judged proper to prevent their entrance as systematic error so far as practicable.

The wind and the waves and currents set up by it in the reservoir, and the friction in the instruments as the lubricant becomes thinner, tend to change in order of time. If the velocities are graded in the same way, beginning at a low speed and making each observation a little faster than the one before, it is not improbable that the condition change may blend with the velocity change, with a consequent distortion of the curve. While no serious error may result from such procedure, it seemed preferable to arrange a programme quickly passing through the range of velocities from slow to fast, then returning to slow again mounting to high speeds, distributing any function of time as an error of observation over all velocities.

The following programme was found satisfactory:

TABLE 2.—*Order of velocities in rating.*

Number on programme.	Velocity in foot-seconds.	Normal revolutions of meter wheels in 200 feet.		Number on programme.	Velocity in foot-seconds.	Normal revolutions of meter wheels in 200 feet.	
		2-B	4-A			2-B	4-A
5......	1.52	143	150	12......	4.55	162	157
10......	3.85	161	157	18......	5.88	163	158
15......	5.26	163	158	8......	2.94	158	156
20......	7.14	163	158	13......	4.76	163	158
6......	2.00	151	153	18......	6.25	163	158
11......	4.17	161	157	9......	3.33	159	156
16......	5.56	163	158	14......	5.00	163	158
21......	7.69	163	158	19......	6.67	163	158
7......	2.50	155	154				

The field criterion used to check the observations is shown in the third and fourth columns. If the registration on the 200-foot base was inconsistent with these values as set down from previous ratings, the meter was overhauled to locate the trouble. If persistent, it was considered normal for the rating in progress, and only values consistent with each other were expected.

The velocities set down are those whose times in crossing the base divide up well for the pacing intervals.

The object of pacing, as used in this work, was rather convenience in carrying out a set programme than to secure great uniformity of speed. The meter should pass the terminal beads at the same speed, since, hanging as it does on a cable, the water resistance swings it back at an angle that varies with the velocity. If the velocity is not the same at the base ends, it is equivalent to lengthening or shortening the base by a small amount.

Aside from this, great uniformity of speed is not essential, for two reasons: First, since the velocities in the river currents are never uniform, but come in pulsations, the same variations of speed were permissible on the rating base, which should reflect the river conditions.

Second, for the meters involved in these gaugings, the rating is so nearly a straight line formula, that the integration of the revolutions caused by varying speeds, within limits, is the same as the total revolutions yielded by a uniform velocity, provided the time in traversing the base is the same in each case.

How little the total number of revolutions of the meter wheel changes for different velocities in measuring a given length of water thread is shown by the following tabulation:

TABLE 3.—*Total revolutions of wheel on 400-foot base.*

	Velocity in foot-seconds.					
	2.0.	3.0.	4.0.	5.0.	6.0.	7.0.
Meter L. S. 4 A.						
Rating:						
October–November, 1899	307.0	314.5	314.9	314.0	314.4	315.4
February, 1900	307.8	311.9	311.8	311.4	311.1	310.9
Meter L. S. 2 B.						
Rating.						
September, 1898	312.6	318.7	321.7	323.5	324.7	325.7
February, 1900	294.6	309.9	316.7	320.2	322.0	322.9
River, 1899	301.0	309.3	312.1	313.8	314.9	315.8

If the meter wheel was drawn through a solid pipe and turned in a screw thread it is evident that it could get through the full length of the pipe only by making a given number of revolutions, and that this number would be entirely independent of the speed at which the wheel traveled, but would depend entirely on the pitch of the thread and the length of the pipe.

This condition is approximated on a rating base between the velocities 3 and 5. Below 3 the revolutions begin to drop off until at 1 foot and below the number is very considerably less.

For the Niagara River discharge measurements the lower velocities are of small moment. In these velocities, however, the rating line shows its maximum curvature, while the error from lack of uniform motion grows with this curvature. Since,

in the river the lower velocities are found near the bottom, the banks, or bridge piers where eddies and rotative motions create the greatest and abruptest speed variations, it is not improbable that an error enters on this account. The measure of this error, however, is not great. Assuming the mean error to be 5 per cent, involving 5 per cent of the volume, it would amount to but a quarter of 1 per cent of the discharge, or perhaps thrice this amount in the bridge section.

The rating base is the only place where the linear unit enters that makes up part of the velocity unit, foot-second.

It should therefore be stated that the interval between terminal beads on the base wire was measured by Chesterman steel tape A, which was used, also, in all other linear measurements pertaining to the discharge of Niagara River.

While suspended the base wire was frequently tested by transit on a measured base on the bank.

With some slight modifications in detail, the methods described were used in the following ratings:

Date, 1899.	Number of observations.	Miles traveled on base.
June 9 and 10	35	2.6
Sept. 28 and 29	10	3
Sept. 30 to Oct. 3	50	3.8
Nov. 17 and 18	62	4.7
June 26, 1900	29	2.2

Twenty observations represented an average day's work. On November 18, 38 double runs of the base were made.

Procedure on the base was simlar to that on the river. Meters were picked up and cleaned at noon as on the catamaran.

Meter L. S. 2 B was rated in Detroit, previous to its shipment to Buffalo, in September, 1898, by Assistant Engineer L. C. Sabin.

It was suspended from a boom projecting about 6 feet forward from the bow of a skiff and drawn back and forth over a measured course alongside a dock, on which the base was indicated by ranges.

One hundred runs were made at various velocities, obtaining 100 observations by a travel of 3.8 miles.

At that time the meter had its standard lead attached. This was replaced in February, 1899, by the 136-pound weight to meet the strong current pressures of the Niagara and all ratings made at the Prospect reservoir were with this heavier lead.

Boat ratings alone have been described thus far, but at the end of the observing season of 1899, after work in the river had been continued until the middle of December, in order to catch the high lake stages that come with the early winter storms and had been abandoned only at the approach of severe winter weather, rating from a skiff was blocked by ice in the reservoir. It was therefore decided to wait until the ice was thick enough to rate with a sled. Thawing weather held this until the following February.

A slot in the ice was then sawed 14 inches wide, about 350 feet long, beginning at the rating dock used in the summer season (so that the meters could be handled by the overhead hoists) and leading along the base wire to 50 feet beyond the second bead. Glare ice was desirable and was maintained part of the time on strips on each side of the slot, by flooding at the end of each day's work for night freezing.

A simple sled was designed and built of pine 2 by 4 with $\frac{3}{4}$-inch round iron runners, 4 feet between centers, turned up at each end so as to travel in either direction. The length of the body was 5 feet. At each end a 5-foot pole was attached, hinged so as to move vertically, but rigid laterally. The sled straddled the slot and the poles were fastened to two guide tubes, sliding on the base wire.

This taut wire served to direct the sled true on its course. A single meter was suspended from the center of the sled and through the ice slot to a depth of about 4 feet.

The cut-off that automatically started and stopped the watch and register, as the zero and 200-foot beads were passed, was mounted on the top of the sled. The electric battery was also carried as part of the load.

The sled was drawn over the course by a team of two men abreast, one at each end of a 10-foot bar (making the running track outside the smooth ice on which the sled moved) which was coupled to the body of the sled by a 15-foot length of wire. The object of a long leading line was to minimize any lateral pull that might come in with a deviation of the team from a straight line and let the base line hold the sled over the center of the slot.

The bar acted as a whiffletree to absorb jerky motions and equalize the pulls.

Above the base wire a tag line was stretched to mark off 25-foot intervals for pacing the running team.

A north run of 200 feet from bead to bead, with the return south run, constituted a rating observation.

Aside from the uncertainty of having ice in good condition in this climate, this proved a most facile method of rating, and the results show a consistency that exceed that of any former work on these meters.

The ice varied in thickness from a foot to 4 inches, and the track conditions ranged from glare ice to slush.

An excellent rating of the B meter was made of 67 observations and a very elaborate rating of the A meter consisting of 173 observations.

This latter was stretched over five days in an attempt to trace the cause of what has appeared elsewhere as a diurnal variation of the rating constants. The several days, however, failed to show any considerable change, and the observations almost deny what is clearly indicated throughout all the two-meter work, and what other ratings made by myself and by other observers show to be a fact. This variation of 1 or 2 per cent on either side of a mean rating line is baffling in the extreme. Whether it is in the manipulation of the instrument or independent of the slight condition changes that may be controlled by the observer, and in the metallic structure of the bearings or the varying pressures of the contact pin, is yet to be solved. As the mean rating of the instrument was known the mean discharge line will be true in spite of this, but the error of individual observations has a wider range.

In coefficient work this was eliminated by comparisons of the two meters employed, as their wheels spun side by side in the river current.

Assuming that the velocity of the current in which the two meters are running is measured by one of them whose rating constants have been established on a still-water base, it is apparent that a series of these simultaneous runs in stations of different velocities constitutes a rating of the second meter.

It is apparent also that any small percentage error existing in the velocities indicated by the first meter will be present in the second as well.

From this it follows that when one meter is rated by comparison with another the two instruments become a compound instrument, and that when velocities are simultaneously measured by the two wheels the ratio of the two velocities is correct, notwithstanding the percentage error in the absolute velocities, since this is eliminated in the ratio by appearing both in the numerator and denominator.

On this principle the two-meter system depends. It is slightly in error in practice, since rating variations do not follow strictly percentage lines. But a small error in small quantities may be treated as a differential of the second degree and neglected. Daily ratings were made in the current as a basis for the value of the revolutions of the B wheel.

Coefficient work in river gauging consists in determining velocity ratios of many points in a station area with respect to some central point.

Discharge observations measured the *absolute* velocity at this central point.

It must be emphasized that these two classes of work furnish two criterions of ratings.

For discharge work the absolute rating is necessary, and this was dependent in the Lake Survey gaugings of this river on still-water calibrations.

For coefficient work, the relative rating is alone required and this was obtained by current comparisons.

This distinction, which is vital, will be made clear by the following parallel:

Revolutions of wheel per second.	1.	2.	3.	4.	5.	6.
Corresponding absolute velocity	1.35	2.57	3.79	5.01	6.23	7.44
Corresponding relative velocity	.270	.513	.756	1.000	1.244	1.485

The relative velocities are here derived from the absolute by dividing through by 5.01, which gives a percentage scale in which the velocity at four revolutions is taken as unity.

In judging the rating used on the meter which measures absolute velocities, the criterion is whether the velocities corresponding to given revolutions are the same as derived by other ratings, and that it is internally consistent.

In passing on the rating used on the meter, measuring ratios, it is enough if the velocity percentages for even revolutions are constant; and two ratings that are widely different in absolute velocities may be in perfect agreement in relative velocities.

A summary of these two classes of ratings is given in Table 4.

TABLE 4.—*Summary of meter ratings.*

Reference number of rating.	Date of rating.	Place of rating.	Rating constants. $v=a+br+cr^2$.			Absolute rating. Revolutions per second.						Relative rating. Revolutions per second.						Meter and lead weight used.	Remarks.
			a	b	c	1	2	3	4	5	6	1	2	3	4	5	6		
						V=velocity per second.						Percentage velocity.							
1	Sept., 1898	Detroit	+0.1163	1.2092	Taken as zero.	1.326	2.535	3.744	4.953	6.162	7.372	26.8	51.2	75.6	100	124.4	148.8	L. S. 2 B 36 pounds.	Still-water base.
2	Feb.-July, 1899	Niagara River	+0.1376	1.1880	....do...	1.326	2.514	3.702	4.890	6.078	7.266	27.1	51.4	75.7	100	124.3	148.6	L. S. 2 B 136 pounds.	Current depends on No. 5, L. S. 4 A.
3	July, 1899	Reservoir, Buffalo.	+0.1238	1.1866	....do...	1.310	2.497	3.684	4.870	6.057	7.243	26.9	51.3	75.6	100	124.4	148.7	.....do......	Still-water base.
4	Sept.-Oct., 1899	.....do........	+0.186	1.199	....do...	1.385	2.584	3.783	4.982	6.181	7.380	27.8	51.9	75.9	100	124.1	148.1	.....do......	Do.
5	Nov., 1899	.....do........	+0.021	1.217	....do...	1.238	2.455	3.672	4.889	6.106	7.323	25.3	50.2	75.1	100	124.9	149.8	.....do......	Do.
6	Oct.-Dec., 1899	Niagara River	+0.1212	1.2437	....do...	1.365	2.609	3.852	5.090	6.340	7.583	26.8	51.2	75.6	100	124.4	148.8	.....do......	Current depends on No. 5, L. S. 4 A.
7	.....do..........	.....do........	−0.0026	1.2617	−0.0026	1.351	2.605	3.854	5.097	6.336	7.569	26.5	51.1	75.6	100	124.3	148.5	.....do......	Same, curve eq.
8	Feb., 1900	Reservoir, Buffalo.	+0.13	1.220	Taken as zero.	1.35	2.57	3.79	5.01	6.23	7.45	26.9	51.3	75.6	100	124.4	148.7	.....do......	Still-water base through ice.
9	.....do..........	.....do........	+0.2899	1.1513	+0.00641	1.448	2.618	3.801	4.998	6.206	7.428	29.0	52.4	76.0	100	124.2	148.6	.....do......	Same, curve eq.
1	July, 1899	Reservoir, Buffalo.	+0.1311	1.24162	Taken as zero.	1.373	2.614	3.856	5.098	6.339	7.581	26.9	51.3	75.6	100	124.3	148.7	L. S. 4 A 48 pounds.	Still-water base.
2	Sept.-Oct., 1899	.....do........	+0.1005	1.2373	....do...	1.338	2.575	3.812	5.050	6.287	7.524	26.5	51.0	75.5	100	124.5	149.0	.....do......	Do.
3	Oct., 1899	.....do........	+0.1033	1.2391	....do...	1.342	2.582	3.821	5.060	6.299	7.538	26.5	51.0	75.5	100	124.5	149.0	L. S. 4 A 136 pounds.	Do.
4	Nov., 1899	.....do........	+0.0460	1.2616	....do...	1.308	2.569	3.831	5.092	6.354	7.616	25.7	50.5	75.2	100	124.8	149.6	.....do......	Do.
5	Oct.-Nov., 1899	.....do........	−0.2345	1.3901	−0.0144	......	......	3.806	5.096	6.356	7.588	......	......	74.7	100	124.7	148.9	.....do......	Do.
6	.....do..........	.....do........	+0.17243	1.1751	+0.0101	1.358	2.563	......	......	......	......	26.6	50.3	......	......	......	......	.....do......	Reverse curve.
7	Feb., 1900	.....do........	−0.0282	1.2918	Taken as zero.	1.369	2.566	3.847	5.139	6.431	7.723	26.6	49.9	74.9	100	125.1	150.3	.....do......	Still-water base through ice.

Upon the completion of the field work of rating, plaster-paris casts were made of the wheels, so that tests could be made now, and again of the blades. The possession of these casts proved valuable on two occasions during the coefficient work on the bridge section. The B meter was fouled in the pier sheathing and the wheel blades bent. A few days later the wheel of the other meter was struck by a piece of ice. Both wheels were trued to fit their casts, with no probable change of rating.

The law which expressed the relation between the wheel revolution and the current velocity was found to be very nearly a straight-line equation in the higher velocities.

In the lower velocities some curvature was shown when the rating observations were platted with the velocities v_1, v_2, etc., as ordinates, and the corresponding revolutions r_1, r_2, etc., as abscissæ.

In the higher velocities also an examination of the residuals obtained by a straight-line equation generally showed slight curvature.

The ordinary equation for rating curve was used

$$v = a + br + cr^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

a, b, and c being the rating constants derived in the solution of the normal equations by the method of least squares.

When c is taken as zero this becomes a straight-line formula

$$v = a + br \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

In this equation the absolute term, a, is positive when the total number of revolutions on the rating base increase as the velocity increases, and negative when the number decreases for rising velocities. The former is the case with the B meter, the latter with the A meter in some ratings.

For the work on Niagara River velocities below 2 feet per second are of very little moment, so little that an error of 5 per cent in them would not amount to an error of one-tenth of 1 per cent in the final result of the discharge. For this reason the rating line below this was ordinarily determined graphically.

The most luminous way found of doing this was by platting the total number of revolutions on the rating base as abscissæ, with the velocities per second as ordinates, and sketching in the line of variation of the total revolutions; then solving the corresponding revolutions per second for a number of velocities and interpolating the balance.

When all observations, high and low, were platted in this way, the rating line for high velocities could be drawn in with an accuracy exceeding one-half of 1 per cent.

After solving a straight-line equation for the higher velocities, the residuals (computed minus-observed velocities), were taken out, grouped for velocity intervals, and platted. This method revealed the line of the A meter to be a reversed curve. An examination of the total number of revolutions on the base shows the same tendency for this meter, as the revolutions reach a maximum at 3-foot velocity and fall off for higher or lower speeds.

The B line is parabolic, with little curvature in high velocities.

These slight curvatures are refinements that need not be emphasized, but were taken into consideration in the reductions.

The velocities derived by curve and straight line formulæ are compared in the summary table. See ratings 6 and 7, and 8 and 9 for A meter.

Rating No. 1 for the B meter was used on all discharge measurements taken with this instrument during the season of 1898 on the bridge section.

Rating No. 5 for the A meter was used for the October–November, 1899, discharges on the open section. The December discharges platted off the line of the previous discharges by using No. 5, but are aligned by using No. 6, which represents the rating of the meter at the close of the season.

For coefficient work on the bridge section the current rating No. 2 of the B meter, which depends on rating No. 5 of the A meter, was used.

The validity of this rating is shown by a comparison with still-water rating No. 3, which immediately followed the coefficient work.

The rating of the B meter used in coefficient work on the open section was No. 6, derived from No. 5 rating of the A meter by 388 side-by-side current comparisons.

That a certain rating was used in coefficient work must be stated, with the reservation that velocity ratios obtained on any day by using two specified ratings of the two meters were corrected by the same percentage as was necessary to apply to the ratios of the meters in the same current to bring them to unity.

From the rating equations, rating tables of absolute velocities were made giving all velocities corresponding to wheel revolutions from 0.00 to 6.00 per second, by 0.01 increments. These were used in discharge work.

For coefficient work, velocity percentage curves were constructed, from which the velocity ratio was taken off directly from the indicated revolutions per second of the two wheels.

This proved of great service in the vast amount of this work done on the two sections. Each day's work in the river on the open section by the two-meter method gave upward of a hundred velocity ratios to solve in duplicate. Without this graphic method of solution the winter office force of four men would have been overwhelmed by the accumulated mass of observations.

The percentage curves gave results accurate to a fifth of 1 per cent, with no systematic error, and were skillfully used by assistants of little office experience.

The correction applied to percentages derived from this curve was indicated by the ratio obtained by speeding the meters side by side. It is evident that the velocity percentage obtained from the curve when the meters run side by side should be 100, but in practice it varied 1 or 2 per cent on either side of this. This was due to the daily fluctuations of ratings before mentioned, and coefficient work done on each day was corrected for this, as follows: When the mean of the daily current ratings indicated by the curve was 102 per cent, it was assumed that all ratios obtained that day were too large by 2 per cent, and each was therefore divided by 1.02. If the mean daily rating showed 98 per cent, all ratios were increased 2 per cent.

The calibration of the instruments is such an important part of river gauging that considerable space has been devoted to describing the methods used on the Niagara River as precedent to their use in current measurement.

In discharge work on the bridge, the B meter was carried on the same reel, mounted on trucks, that was used in sounding. Each revolution of the drum reeled off exactly 5 feet of the quarter-inch steel cable, by which the meter was suspended. Electric connections between the meter cable on the moving drum and the stationary batteries (which were carried in a box beneath) was maintained by brass springs bearing against concentric brass rings on the head of the drum.

From the drum the cable led up over a pulley on an overhanging arm which swung the meter clear of the hand rail of the bridge, so that it could be dropped between the eyebars of the lower chord to the water.

With the meter at the index, which was approximately at three-tenths depth at each station, a two-minute run was made. The meter was then wheeled to the next, and to all stations successively, taking a two-minute measurement of the current speed at each. The mean length of current thread measured at stations was about 650 feet in the run of 120 seconds, being more than this in the mid-river spans, and less toward the shore.

The observing party consisted of five men—the observer, the recorder, two men on reel, and one watchman to warn the party of the approach of trains, and to keep a lookout for drift that might injure the meter.

It took from an hour and a half to two hours to measure a discharge.

The location of the meter at the index depth was somewhat complicated by the swinging of the instrument downstream by the current, with a resulting inclination of the cable, which was different from each lake stage. By taking the angle that the cable made with the vertical at mean stage for each of the swift-water stations, the amount of cable to reel off after the meter axis was at water service was computed for each.

To this was added algebraically for any other stage three-tenths of the change in the section gauge.

The precedent of making no correction for the greater inclination of the cable under high velocities, established by the Board of Engineers on Deep Waterways, was followed in the lake-survey discharges.

As the velocity ratio is so nearly constant close above and below the three-tenths depth, the dipping of the meter a foot or two below the proper index depth in low stages, and rising as much above it in high, which with this amplitude was confined to the deepest, most rapid stations, resulted in no great inaccuracy. This range was much reduced in the winter and spring of 1899 by the use of the 136-pound lead on the B meter instead of the standard 36-pound one.

In coefficient work the A meter was set at the index more closely than in discharge observations, and the B meter, with its great weight, was placed accurately in its proper position in the vertical by corrections that took into consideration the curvature of the cable below water and the inclination above, as detailed in the discussion on methods of sounding.

Coefficient work was carried on with two meters, the A meter at the index, while the B meter made simultaneous runs, obtaining the velocity ratio directly for as many points in the station area as was judged desirable to establish the mean velocity ratio.

Coefficient work follows essentially a cross-sectioning process, similar in many respects to earthwork measurement. Its object is to find the volume of water at the mean section-gauge height passing a station area when the index velocity is taken as unity. This volume, divided by the cross-sectional area developed by the soundings, gives the mean velocity as a percentage of the index velocity.

This is the velocity coefficient, which reduces the product—the cross-sectional area into the velocity obtained in a discharge measurement—to station volume of flow.

In such a section as that of the international bridge the proper derivation of the velocity coefficients is the most difficult part of the river gauging.

To obtain it the writhing mass of water streaming through the bridge openings and eddying about the piers, spurting and lagging in minor pulsations, speeding faster as the lake rises and flowing leisurely in low stages, must be congealed to a solid by some instantaneous method of survey, and its dimensions taken.

The two-meter method of work was the instantaneous process used to attain this result.

With all its variations of velocities a law of flow is followed by which percentage velocities tend to remain constant. If the current threads speed up at the index where the A meter was placed, it quickens proportionally 20 feet away, where the B meter is spinning; so that, with a large range in absolute velocities, so long as the relative position is held, the ratio, B's velocity divided by A's velocity, tends to remain constant.

The abruptly changing conditions of the bottom at the bridge made it necessary to observe velocity percentages from surface to bottom at many substations. This was done on all the regular substations—about 20 feet apart—into which each station was divided; and in addition pluses were put in near the piers, and wherever else the conditions seemed to indicate a possible change.

The following summary shows the number of points at which these vertical curves were measured in each station area:

Summary of vertical curves, bridge section.

Span.	Index station.	Number of curve stations.	Span.	Index station.	Number of curve stations.
2	2	5	5	10	6
2	6	5	6	2	6
3	2	5	6	6	4
3	6	6	6	10	5
4	2	7	7	2	7
4	6	4	7	6	6
4	10	4	8	2	7
5	2	7	8	6	6
5	6	4			

Curves were taken in spans 1 and 9 at all substations, but were not used, coefficients previously derived being accepted.

A duplicate set of observations was made on each curve. Beginning just below the surface, the B meter was started simultaneously with the A meter (which remained at the index), and both stopped at the end of four minutes. This was repeated at different depths until the B meter reached bottom. The B meter, then observed at the same depths as it was brought upward, obtaining a duplicate set of percentage velocities. As the observations were made, they were reduced and platted on the bridge, and any showing widely different from its original, or off the line traced by the others, was again repeated.

Guys above water were used to hold the B meter from sagging downstream in the strong current. Side-by-side ratings of the two wheels maintained the integrity of the compound meter.

These ratings were ordinarily carried on as follows: The A meter was set at 5 feet depth, well away from the piers; the B meter was set at same depth, abreast, and about 4 feet west of it.

Two or three 2-minute runs were then made simultaneously, after which the B meter was placed the same distance east of the A and the observations repeated. Observing east and west of the B meter eliminated the effect of the change of velocity along the section.

This current rating was repeated for different velocities.

Early in the observations the importance of this as a basis of corrections was not fully grasped and the ratings were not always made daily, but enough were made to give an excellent key for interpolation.

It will be observed that what have been mentioned as vertical curves are, more accurately, vertical-transverse curves, because each point has been referred to the index, which involves the change in velocities latterally as well as vertically, so that the mean ordinate of any of these curves is the vertical-transverse coefficient for the substation which it governs.

The third element that enters into the substation coefficient is the direction coefficient.

The direction of the current flow was not, as a rule, at right angles to the bridge, but at mid span the trend was 2 or 3 degrees to the eastward, and nearer the piers was deflected from them, so that for each opening the threads tended to converge in a vena contracta.

The surface indication of the direction was taken as the direction at all depths, and the angle taken by a 20-foot line flush with the water surface, to which was attached a weighted float, while the upstream end was attached to the weight of the B meter lowered from the south side of the bridge just below the water, was accepted as a basis for direction coefficient.

This was observed for all substations, and additional observations were put in around the piers.

The influence of the direction element on the measured discharge is minute, almost negligible.

With the many substation coefficients, transverse, vertical, and direction, which combined make the required velocity coefficient, the proper methods of combining them to arrive at an accurate result is important.

In discussing the methods used to compute the volume of river flow, it will be necessary to derive some equations that are fundamental in an elementary manner.

This is peculiary true of those involving the velocity coefficient. As the conditions at the bridge section are such as to call for the observance of accurate methods in the derivation of this ratio, instead of the more simple approximations that may be safely used in an unbroken stream, the detail of the theory on which it was computed is given.

It has been demonstrated in river hydraulics that the velocities throughout a certain area maintain definite percentage relations, and when these relations are firmly established by ample observations, a single known velocity is the key to all others simultaneously existing, and hence to the discharge in the area involved.

On this characteristic of river flow are based the methods used to determine the volume of water which the river carries in its various stages and conditions. Like most hydraulic laws, this has its limitations, and is more nearly absolute as the area considered approaches an element of river width.

How accurate it is for the full river width is shown by the following tabulation, in which the mean velocities for each station derived from groups of discharge measurements are expressed as percentages of the mean velocity of all stations for the same group.

OPEN SECTION.

TABLE 5.—*Index velocities as percentages of mean index velocity.*

	Group No.						Total.	Weighted means.
	1.	2.	3.	4.	5.	6.		
Number of observations in group	10	10	10	10	10	7	57	
Elevation of lake gauge	572.0	571.4	571.2	571.1	570.9	570.5		571.2
Mean index velocity	4.84	4.58	4.51	4.45	4.38	4.21		4.51
Station—								
1	42.6	33.9	28.4	23.5	25.6	29.2		30.6
2	81.3	79.0	78.6	77.6	77.3	77.2		78.5
3	95.9	96.8	97.7	99.7	98.8	97.6		97.8
4	104.5	105.1	105.4	106.0	106.7	106.2		105.6
5	126.6	127.8	129.3	127.9	128.1	126.6		127.8
6	129.2	130.5	133.1	133.0	134.4	136.1		132.5
7	124.1	125.1	126.1	126.4	125.6	125.7		125.5
8	121.3	122.9	124.6	124.9	124.5	123.3		123.6
9	118.2	121.1	120.5	121.4	121.6	122.1		120.7
10	108.9	110.5	110.3	110.4	110.7	112.4		110.4
11	107.7	110.6	110.7	111.9	110.8	110.2		110.3
12	106.7	107.6	106.9	108.6	108.3	109.5		107.8
13	92.6	93.5	91.9	92.7	91.2	91.9		92.3
14	100.0	99.8	99.3	99.9	101.0	98.8		99.9
15	92.4	90.9	91.3	90.4	91.8	90.7		91.3
16	84.1	84.3	84.6	84.2	83.7	83.1		84.0
17	64.1	64.9	61.4	62.1	61.0	59.9		61.8

No serious error will enter from the proposition of fixed relations within the area limited by a proper station width.

It is apparent, however, that velocities will maintain their relation the more accurately as they are closer together, and for this reason the point which is selected as the key to a station discharge should be centrally located in its area. This consideration would point out the center of figure as the desirable location, but a modification of this grows out of the fact that it is more important to know accurately the velocity ratios of the high speeds where the greatest discharge occurs than those of the low. It would therefore seem that the center of gravity of the solid figure in which a second's discharge may be conceived to congeal is the proper location of this point.

As has been stated before, since the velocity here is taken as indicative of the station discharge, this point has been called the index.

Other practical considerations generally prevail to put the index at mid-station, and at a lesser depth than the gravity center. In the bridge section it was taken at three-tenths depth and in the open section at four-tenths depth. The center of gravity would fix it between four-tenths and mid-depth.

For gauging purposes the river width having been divided into N stations of such size that the index in each will accurately reflect changes throughout, the discharge of the river must be the summation of the partial discharges in all these stations.

$$\text{River discharge} = Q_1 + Q_2 + Q_3 + \text{------} Q_n \quad \ldots\ldots \quad (1)$$

in which Q is the station discharge, with subscript indicating the particular station.

If the station width is divided into n substations, so small that each may be treated as an elementary area and the discharge in each of these substations be denoted by q, with proper subscript, the station discharge is the sum of all these elemental discharges.

$$\text{Station discharge} = Q = q_1 + q_2 + q_3 + \text{------} q_n \quad \ldots\ldots \quad (2)$$

From the law of fixed velocity relations, a velocity measured at some point in the substation area bears a certain ratio to the mean velocity of the substation. Let this point be at the subindex, which is at the same percentage depth as the index; let v be the velocity there and c a ratio, such that

$$cv = \text{Mean velocity in substation} \quad \ldots\ldots \quad (3)$$

If a is the corresponding cross-sectional area, the discharge is

$$q = cva \quad \ldots\ldots \quad (4)$$

Thus far it has been assumed that the current cuts the section at right angles or squarely. If, however, it makes some angle, α, with a normal to the section, only that component of the velocity which parallels this normal must be taken. This component of the velocity v, is cosine αv, letting cosine α be represented by d, the factor d enters equation (4), giving

$$q = dcva \quad \ldots\ldots \quad (5)$$

The station discharge then becomes from (2) and (5).

$$Q = d_1c_1v_1a_1 + d_2c_2v_2a_2 + d_3c_3v_3a_3 + \ldots \quad d_nc_nv_na_n \quad \ldots\ldots \quad (6)$$

or, more briefly,

$$Q = \Sigma dcva \quad \ldots\ldots \quad (7)$$

By the same law of fixed relations which permitted a ratio, c, to be found for the substation, a coeficient, C, may be established to reduce the measured velocity, V, at the index to the mean normal velocity of the whole station, whose cross-sectional area is A. Then—

$$CV = \text{mean normal velocity of station} \quad \ldots\ldots \quad (8)$$

and

$$CVA = Q = \text{station discharge} \quad \ldots\ldots \quad (9)$$

and from (7) and (9) results

$$CVA = \Sigma dcva \quad \ldots\ldots \quad (10)$$

Dividing this by VA gives the value of C

$$C = \Sigma dcv^o a^o \quad \ldots\ldots \quad (11)$$

In this equation C is the velocity coefficient required, c is the vertical coefficient for substations, d is the direction coefficient for substation, v^o is the percentage velocity of each subindex referred to in index velocity as unity, i. e.,

$$v^o = \frac{v}{V}$$

a^o is the ratio of each substation area to the total cross-sectional area, i. e.,

$$a^o = \frac{a}{A}$$

Of these quautities d, c, and v^o may be taken as constant for any substation, while a^o with sloping bottom is variable, since a change of stage in such a case makes a greater percentage change in the depth of shallower water than it does in the deeper substations, a and A not changing by equal percentages, their quotient becoming variable.

Since one of the components of C may be variable, the coefficient itself may be variable.

It is seen, since $\Sigma a^o = 1$, that C is a weighted mean of the products dcv^o of the several substations, and that the weights are (a^o_1, a^o_2, a^o_3, etc.) the substation percentage areas.

In a station with inclined bottom—as the water is slower, as a rule, in the shallower portions than where it runs deep—the value of v^o is proportionally smaller. Assuming in such a case the values of d and c to be uniform throughout the station, C will in general show descending values for rise of gauge. However, as in other cases, large values for d and c may offset a smaller v^o, no law of C's variation can be set down.

Where the bottom is level in the station, since $\frac{a}{A}$ is constant, C becomes constant.

When the values of d and c are the same for the several substations, equation (11) becomes

$$C = dc\Sigma v^o a^o \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

The velocity coefficient, C, is then the combined product of the direction and vertical coefficients into the weighted mean of the velocity percentages of the index and the subindexes.

With level bottom and substations of equal width, the values of a^o become alike for all.

$$a^o = \frac{a}{na} = \frac{1}{n}$$

and equation (11) becomes

$$C = \frac{\Sigma dcv^o}{n} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (13)$$

and (12) changes to the simple form

$$C = dc\frac{\Sigma v^o}{n} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (14)$$

Equation (14) is of very wide use. The fraction $\frac{\Sigma v^o}{n}$ may be called the transverse coefficient.

A value for C, which is the product of the three coefficients of direction, vertical, and transverse, may be used only where the bottom is level, the substations of equal width, and the direction of flow and the form of the vertical uniform throughout the station.

This applies for the most part to the stations of the open section. Equation (11) is applicable to the bridge section, and was used in the derivation of the velocity coefficients.

The observations in the vertical of each substation and plus station were platted with percentage velocities referred to index as abscissæ and depths as ordinates. A smooth curve was then drawn through the observations from surface at mean section gauge to bottom, and the mean percentage velocity, $c\,v$, computed. The area between two vertical curve stations was taken as governed by the mean $c\,v$.

This mean was corrected for direction and combined with the other $c\,v\,d$ products of the remaining stations in proportion to its area of cross section.

A second combination of the same $c\,v\,d$ products was made with the percentage areas corresponding to a rise of section gauge of 2 feet. This in some cases showed variable coefficients decreasing with rising gauge.

The derived coefficients at different river stages for the two sections as well as the corresponding cross-sectional areas are given in Table 6.

TABLE 6.—*Cross-sectional areas and coefficients for each station.*

BRIDGE SECTION—CROSS-SECTIONAL AREAS.

Section gauge height.	Span 1.		Span 2.		Span 3.		Span 4.			Span 5.			Span 6.			Span 7.		Span 8.		Span 9.	
	Station 2–8.	Station 6–8.	Station 2–8.	Station 6–8.	Station 2–8.	Station 6–8.	Station 2–12.	Station 6–12.	Station 10–12.	Station 2–12.	Station 6–12.	Station 10–12.	Station 2–12.	Station 6–12.	Station 10–12.	Station 2–8.	Station 6–8.	Station 2–8.	Station 6–8.	Station 2–8.	Station 6–8.
568.5	609	874	927	1,021	2,171	2,174	2,741	3,908	3,174	3,240	3,302	2,785	2,713	2,904	1,703	2,033	1,969	1,538	1,381	176	215
568.0	571	836	889	982	2,132	2,136	2,702	3,868	3,135	3,201	3,262	2,746	2,673	2,865	1,664	1,986	1,922	1,492	1,335	141	177
567.5	533	798	850	944	2,092	2,097	2,664	3,828	3,096	3,162	3,222	2,707	2,633	2,827	1,625	1,939	1,875	1,446	1,289	407	140
567.0	495	761	812	905	2,053	2,059	2,625	3,788	3,058	3,123	3,182	2,668	2,593	2,788	1,586	1,892	1,829	1,400	1,242	372	104
566.5	458	723	773	867	2,013	2,020	2,586	3,749	3,019	3,084	3,142	2,629	2,553	2,750	1,546	1,846	1,782	1,354	1,196	338	71
566.0	420	685	735	828	1,974	1,982	2,548	3,709	2,980	3,046	3,102	2,590	2,513	2,711	1,507	1,799	1,735	1,308	1,150	303	41
565.5	382	647	696	790	1,934	1,943	2,509	3,669	2,942	3,007	3,062	2,551	2,473	2,673	1,468	1,752	1,688	1,262	1,104	267	....
565.0	345	610	658	751	1,894	1,904	2,471	3,629	2,903	2,968	3,022	2,512	2,433	2,634	1,429	1,705	1,641	1,216	1,058	231	....

BRIDGE SECTION—MEAN VELOCITY COEFFICIENTS.

568.5	0.818	0.581	0.932	0.944	0.828	0.807	0.876	0.917	0.836	0.844	0.906	0.859	0.834	0.873	0.774	0.739	0.846	0.868	0.915	1.084	0.952
568.0	.818	.581	.933	.945	.829	.807	.876	.917	.837	.844	.906	.860	.834	.873	.776	.740	.847	.868	.915	1.084	.952
567.5	.818	.581	.934	.946	.830	.808	.876	.917	.838	.844	.906	.860	.834	.873	.778	.741	.848	.869	.915	1.084	.952
567.0	.818	.581	.935	.947	.830	.808	.876	.917	.839	.844	.906	.860	.834	.873	.780	.742	.849	.869	.915	1.084	.952
566.5	.818	.581	.936	.948	.830	.808	.876	.917	.840	.844	.906	.860	.834	.873	.782	.743	.850	.869	.915	1.084	.952
566.0	.818	.581	.937	.949	.831	.809	.876	.917	.841	.844	.906	.860	.834	.873	.784	.744	.851	.870	.915	1.084	.952
565.5	.818	.581	.938	.951	.831	.809	.876	.917	.842	.844	.906	.861	.834	.873	.786	.746	.852	.870	.915	1.084	.952
565.0	.818	.581	.939	.952	.832	.809	.876	.917	.844	.844	.906	.861	.834	.873	.788	.747	.853	.871	.915	1.084	.952

OPEN SECTION—CROSS-SECTIONAL AREAS.

Austin street gauge height.	Station 1.	Station 2.	Station 3.	Station 4.	Station 5.	Station 6.	Station 7.	Station 8.	Station 9.	Station 10.	Station 11.	Station 12.	Station 13.	Station 14.	Station 15.	Station 16.	Station 17.
568.0	610	1,718	3,122	3,587	3,561	3,528	3,524	3,576	3,263	3,112	2,928	2,498	2,310	2,148	1,798	1,426	1,074
567.5	560	1,668	3,072	3,537	3,511	3,478	3,474	3,526	3,213	3,062	2,878	2,448	2,260	2,098	1,748	1,376	1,014
567.0	510	1,618	3,022	3,487	3,461	3,428	3,424	3,476	3,163	3,012	2,828	2,398	2,210	2,048	1,698	1,326	954
566.5	460	1,568	2,972	3,437	3,411	3,378	3,374	3,426	3,113	2,962	2,778	2,348	2,160	1,998	1,648	1,276	894
566.0	410	1,518	2,922	3,387	3,361	3,328	3,324	3,376	3,063	2,912	2,728	2,298	2,110	1,948	1,598	1,226	834
565.5	360	1,468	2,872	3,337	3,311	3,278	3,274	3,326	3,013	2,862	2,678	2,248	2,060	1,898	1,548	1,176	774
565.0	310	1,418	2,822	3,287	3,261	3,228	3,224	3,276	2,963	2,812	2,628	2,198	2,010	1,848	1,498	1,126	714

OPEN SECTION—MEAN VELOCITY COEFFICIENTS.

568.0	Volume taken from table.	0.937	0.927	0.932	0.933	0.933	0.933	0.939	0.927	0.907	0.903	0.921	0.935	0.917	0.914	0.925	0.863
567.5		.9325	.9235	.9285	.9294	.9295	.9295	.9355	.9235	.903	.899	.9165	.932	.9145	.910	.918	.855
567.0		.928	.920	.925	.926	.926	.926	.932	.920	.899	.895	.912	.929	.912	.906	.911	.848
566.5		.9235	.9165	.9215	.9225	.9225	.9225	.9285	.9165	.895	.891	.9075	.926	.9095	.902	.904	.840
566.0		.919	.913	.918	.919	.919	.919	.925	.913	.891	.887	.903	.923	.907	.898	.897	.833
565.5		.9145	.9095	.9145	.9155	.9155	.9155	.9215	.9095	.887	.883	.8985	.920	.9045	.894	.890	.826
565.0		.910	.906	.911	.912	.912	.912	.918	.906	.883	.879	.894	.917	.902	.890	.883	.819

It will be noted that the level-bottomed stations $4\frac{6}{12}$ and $5\frac{6}{12}$ have constant coefficients for all stages.

The coefficients for spans 1 and 9 were not computed by the Lake Survey, but were accepted from the earlier values derived by the Board of Engineers. Discharges had been computed for these, and it meant more work to get out new coefficients and recompute the volumes in these stations than time was available for; and in the end the game was hardly worth the candle, since the flow of water in the spans in question is but 1.2 per cent of the river flow, and any change in them the later data might make would be a negligible volume.

The discharge in station $1\frac{2}{8}$ is effected to a considerable extent by the late summer's growth of aquatic weeds. It will be shown later in discussing the gauges that this water vegetation is responsible for a yearly cycle in the river slope that is not improbably accompanied by a seasonable change of small amount in the river discharge for a fixed lake stage.

Table 6 gives, in connection with the section gauge heights and the index velocities observed in a discharge measurement, all data necessary to compute the volume of flow.

The discharge for any station has been stated to be

$$Q=CVA \quad . \ . \ . \ . \ . \ . \ . \ . \quad (9) \text{ (page 26)}$$

For any fixed height of section gauge, as 567, C and A are constants; taking Q equal to 10,000 cubic feet, equation (9) becomes

$$V=\frac{10,000}{CA} \quad . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \quad (15)$$

When the section gauge is 567 this is the index velocity corresponding to a discharge of 10,000 cubic feet. One-tenth of this is the velocity increment for each additional 1,000 feet of water.

A sheet was prepared with the section-gauge heights as ordinates and the index velocities as abscissæ, and on the horizontal line corresponding to gauge 567 points were platted at the velocities necessary for volumes 7,000, 8,000, 9,000, 10,000, etc. (See plate.)

The same process was repeated for gauges 567.5, 568, 568.5, and for each half foot below 567. The curved line passing through the 10,000-foot points traces the locus of this volume of discharge for all combinations of index velocity and gauge.

The lines through the 7,000, 8,000, 9,000, etc., foot points complete the even thousand-foot discharge loci. Between these were interpolated loci for each increment of a hundred cubic feet of discharge.

One of these sheets was made for each principal station, 17 in all for the bridge section and 16 for the open section.

A discharge observation gives the index velocity and the section gauge, so that from the sheet the station volume of flow is taken off directly to the nearest 10 feet.

The discharge-computation curve is a labor-saving device. Including the time for computing the data and constructing the curves (about two hours for each station curve), it is estimated that the volume of flow may be gotten from a set of these in a third the time necessary to compute it; and assistants inexperienced in calculations readily do accurate work in this way.

The volume was taken out for all discharges in duplicate. The second time the points were platted with the discharge number on each sheet, so that when all the computations were made the curve sheets had been converted into plats showing the law of discharge for each station. Observations that fell wide of the line marked by the majority were traced back through the notes for clerical errors.

As the discharge volume as derived for the bridge section is practically the same as that computed for the open section, and as both depend on the generating hydraulic head of Lake Erie, as interpreted by the gauges, the results must be reserved until the processes of the check section are more fully explained and the correlation of the gauges with the velocity work is made clear.

The open section lies downstream, or north of the bridge a little over 1,800 feet, being well toward the foot of Squaw Island. It would have been well to have gotten farther away from the bridge, with its broken currents, if a good section had been available. A section above the bridge was recommended, but not used for fear of the catamaran being thrown against the masonry of the bridge.

Aside from a trace of the wake of the bridge piers, however, the open section is an excellent one. It is compact, with a well-graduated bottom profile. The current is positively free of eddies, and comes from the bridge on a long straightaway course, with a mean index velocity of about 4.5 feet (for the October–December, 1899, observations).

Squaw Island, flat and unobstructed, gave a range site that could only have been bettered by adding a similar stretch on the Canadian shore.

A front range was set up on Squaw Island, and a back range was mounted on the top of the masonry wall of a ruined mill on the main shore, to align the survey boat on the section. (See plate 2.)

Beginning at this front range, a base line was measured, at right angles with the section, toward the south a thousand feet long.

At the south end of this base a post 8 inches in diameter was set. Its top was 5 feet above the ground, and leveled to act as a transit mount when desired, and to carry, ordinarily, a fore sight to cut off the meter stations on the discharge section. This fore sight was of $\frac{7}{8}$-inch round iron, bent into the form of an arrowhead 2 feet high, fastened by lag screws to the post. White cotton cloth was spread over it. The post and range were made exceptionally strong, to meet the attacks of the swarm of urchins that makes of this island a swimming rendezvous, and stood the test. The back cut-off ranges used in connection with this, one for each meter station, were set about a thousand feet southeasterly from this, on the slope of the railway embankment for the most part. The luminous part of these ranges was a panel of white cotton cloth stretched on a frame of pine. On the ranges for stations 5, 10, and 15 triangular shapes were used about 3 feet high; on all other back cut-off ranges rectangular panels 16 by 36 inches. No difficulty was therefore experienced in knowing the range for a particular station. The use of cloth through which the sun shines gave a brilliant target, never in shadow.

The angle a, turned off from the 1,000-foot base line for any station, is derived from the simple relation

$$\frac{\text{Normal distance from base line to station}}{1{,}000} = \text{tangent } a.$$

In sounding at 10-foot intervals on the section the survey boat was located by transitman at fore-sight post.

In coefficient work at substations supplementary movable back cut-off ranges were put in place as required.

The section was accented, in addition to the ranges, by the terminal cribs that were put in to support the long-range gauges near either shore.

The angle between the line of the range and the section for Station 16 was the most acute, being 30° 2′.

Station 17 was measured off from the west crib by a 60-foot tagged line during the season of 1899. This crib was not replaced for the brief time of work in 1900, and a cut-off range was set up on the Canadian shore to get the station location.

Station 1 was 50 feet from the east crib. All station lengths were 100 feet except 17, which took the excess measurement and was 120 feet.

The fleet lay in the Austin street slip, just below the open section at the dock of the Buffalo Smelting Works. The Lake Survey is indebted to the superintendent, Mr. M. B. Patch, for the privilege of using their wharf, not only as a landing place, but as the site for gauge and gauge house No. 12 and a small warehouse. As the grounds of the smelting works are inclosed and continually under the eye of a watchman, the security from meddlers was of much value.

The tug *General G. K. Warren*, 69 feet over all by 15 feet beam, with a simple upright engine, has proved adequate to handle the catamaran quickly in the strong river currents. She is stiff and strong, and with light draft of 4.5 feet is admirably adapted for the purposes of the Survey. She has since been renamed *Lake Survey No. 1.*

Catamaran No. 2 is composed of two steel hulls of whale-back type, 28 feet long by 5 feet beam with about 1 foot draft.

The hulls are connected by steel trusses that carry a deck of pine 16 feet fore and aft, 21 feet beam, and 30 inches above the water surface.

As used in meter work on the river, she was equipped with a bow windlass having a drum 5 feet in circumference, from which the headline of galvanized-iron wire leads through a bow chock with lignum-vitæ pulleys to the anchor buoy 1,700 feet upstream.

Simple oak port and starboard windlasses were hinged on each side so as to overhang the deck and handle the masses of iron used as side anchors to hold the catamaran steady in the current. Galvanized-iron wire was used on side anchors.

For handling the meters, two reels, one being the Bridge reel previously described, adapted for boat work, and the other similar in principle, were placed well toward the stern, their cables leading to pulleys on overhangs forward of the deck, so that the meters entered the water abreast about 4 feet apart.

The rudders of the two hulls were controlled by a wheel just astern of the bow windlass.

The catamaran was accompanied by a skiff; and the tug, during observations, lay below the section in slack water toward shore, in waiting for flag signals from the observing party.

The full catamaran party consisted of the observer, a recorder, a wheelman, and three reelmen, who handled the head and side windlasses in getting on range and placed the meters at the proper observing depths as called out by the observer.

The tug crew was composed of master, engineman, fireman, and deckhand.

The regulation discharge programme began the day's work at Station 17, and by noon a measurement of all stations had been made, ending at station 1, where the catamaran lay during lunch hour. During the afternoon a second discharge was measured, beginning at 1 and ending at 17.

How to manipulate the catamaran rapidly in passing from station to station and to hold it steady on the station during the progress of the meter work was a matter of some experiment. The use of a headline to sustain the catamaran and to swing on as a radius, to be reeled in or paid out to get on the section ranges, was a foregone conclusion; and further, that this must be of wire or wire cable, so as to cut the current pressure down to its lowest terms, grew out of our soundings experience. It was found that No. 9 galvanized-iron wire was a cheap and satisfactory swinging line.

Another conclusion formed prior to the arrival of the fleet was the use of fixed anchorages to take the upstream end of the headline to swing on as centers. Four of these were set in the early trials, each consisting of two pieces of scrap iron 320 and 150 pounds, respectively, and a 50-pound fluke anchor, all chained together tandem (the anchor last) and attached with about 150 feet of chain and manila rope to kerosene-barrel buoys.

These were placed about 1,200 feet above the section, at about equal intervals across the river. The catamaran made easy work of dragging these downstream; so it was decided to extend the swinging line and utilize the bridge piers as anchorages.

Eyebolts were set in the masonry of two of the piers and kerosene barrels dropped downstream 120 feet on $\frac{3}{4}$-inch manila line, which permitted the tug to hook the headline to rings on them without the danger of a nearer approach to the stonework.

A third point for taking the headline was set on the rest pier of the drawbridge, where the tug could moor alongside the cribbing.

A certain amount of elasticity was needed in the swinging line to take up sudden stops, and this was provided by making the upper 500 feet of the line of $\frac{3}{4}$-inch diameter rope.

A "stopper" or branching rope was spliced into this near its upper end, so that the tug picking up this relieved the pull on the barrel, unhooked the swinging line and moved it to the next barrel, the catamaran still remaining on the section. This move was made twice for each discharge measurement, and took from five to ten minutes each time.

The swinging line was floated clear of the bottom by five galvanized-iron buoys spaced at about equal intervals along it. These had cylindrical bodies 10 inches in diameter and in length, with cones of the same length at each end carrying rings at the extremities.

Their buoyancy was about 40 pounds each. They were bound to the swinging line by marline, that was cut as the line was rapidly reeled in at the end of the day's work.

Chunks of scrap iron weighing about 150 pounds were used on the No. 9 galvanized-iron wire side lines for anchors. These were lost occasionally as the wire broke. This was accepted as part of the legitimate cost of the work. The current pressure was so great that any anchors that could be handled with the facility demanded by quick maneuvers were carried downstream when rope even as small as $\frac{5}{16}$-inch diameter was used. Fluke anchors would not take hold for cross-current pulls, and their value made their use on wire lines out of the question.

This strength of current, that compelled new methods in getting soundings, made big lead weights necessary for accurate meter locations, and tested our resources in holding the survey boat fixed on a station, proved the source of the rapid evolutions made in discharge operations.

When thrown by the rudders at a diagonal with the river direction the catamaran moved swiftly across the current.

The zigzag path taken by the boat in placing her side anchor, getting in position on the station, and picking up the anchor again seems intricate and slow, but in practice it was done so speedily that four minutes measure about the average time between observations at consecutive stations.

With catamaran in position at Station 17, operations are as follow: Let go shore line, dropping starboard anchor at same time; swing to 16, paying out starboard-anchor line; hold position at 16 by opposing rudders to the pull of the anchor line, and

observe; swing back to 17, reeling in anchor line, and raise anchor clear of bottom; swing to 15, dropping starboard anchor as 16 is passed; hold position at 15 and observe; swing back to 16 and raise anchor off bottom; swing toward 14, dropping anchor at 15; observe at 14; swing back and pick up starboard anchor; swing now to 12 and drop the port anchor, returning to observe at 13; move anchor to 11; observe at 12; swing anchor to 10 and observe at 11, signaling tug to move head line to mid-river barrel, etc. The head reelman had meanwhile, by taking in or paying out on the bow windlass, held the catamaran on the section.

The tug is equipped with a steam capstan for handling anchors, but since reelmen had to be employed to handle lines they were available for the side-anchor work, with a gain in speed that resulted in additional observations.

The catamaran as designed carries a house to shelter the observer and permit field reductions and records to be made with greater facility. As, however, in Niagara River the heavy windstorms come from the southwest and add wind pressure to the force of the swift current running at such times, it seemed advisable to reduce the wind surface to a minimum. The house was set up on the dock and used as a storeroom, and the catamaran went into action stripped for battle. In this way storm values for the discharge have been derived and investigations of wind effects on the vertical curve have been possible in the severest gales.

In September observations the single meter B was dropped into the water through a trap toward the stern end of the deck.

When the two-meter work began in the beginning of October the instruments were let down from overhangs about 2½ feet forward of the deck. Later it was established that the meters entered the zone of the catamaran's influence as they neared the water surface. The overhangs were extended November 6 so that the wheels were 1½ to 2 feet beyond the bows. As the clear waterway between the hulls is over 11 feet and the meters were side by side in the middle of this space laterally as well as forward of the bows, it is believed that the resulting surface measurements were unaffected by the presence of the survey boat.

The effect on the vertical curve in the previous meter positions was confined to the upper observations and did not extend to the index at the four-tenths depth. All coefficient observations above the index taken during this time were rejected as an extreme precaution.

That no distortion of the accepted vertical curves is present may be gathered from the general similarity of the verticals of the open section to those of the bridge section.

The programme arranged for the open-section work was based on the following considerations:

1. Since a considerable time is occupied in getting located for a station observation, a weightier aggregate of discharge observations can be gotten by longer runs of the index meter at each station. Instead, therefore, of observing at each index 100 seconds, as had been the practice of the Board of Engineers, on the bridge, or 120 seconds as the Lake Survey did on that section, the standard time at the index was made 360 seconds in three consecutive runs of two minutes each.

2. If three points on the vertical curve of each station could be fixed by a great many observations and these three points were the surface, the index, and the eight-tenths depths, little doubt would remain as to the path of the curve. It was therefore decided to observe at the surface and the eight-tenths depth with the B meter in simultaneous two-minute runs with the A meter, while the latter instrument was making its regulation absolute velocity measurement at the index. The ratio of velocities to the index velocity for the two indicated points were thus obtained, while the ratio for the third point, the index, is unity.

3. The instrument used being compound, its integrity must be maintained by current ratings. For this reason at every other station the B meter was run side by side with the A meter at the index. At the alternate stations, where the rating was omitted, the B meter took the bottom velocity, adding a fourth point to the fixed points on the vertical. On the second discharge measurement the ratings were taken at the stations omitted in the morning's observations, the bottom vertical point being taken where missed in the first discharge.

On some days eight minutes were given to each station and an additional point on the vertical observed.

In the discharge observations of 1900 the curves are being strengthened by observing for fixed vertical points at the surface, the six-tenths, and the nine-tenths, in addition to ten ratings a day at the index.

4. It seemed desirable to test the constancy of form of the vertical curve under different gauge and wind conditions. To do this the index was taken at a constant elevation and not raised with rise of gauge, and points in the vertical that have been spoken of as at certain tenths of depth were likewise invariable.

Points in the vertical were taken every 2 feet at 565, 563, 561, etc., to bottom, the elevations being above mean tide, New York.

If, in a level-bottomed station, a constant velocity coefficient would be derived by making the index at a percentage depth, as was done on the bridge section, the result of holding it at a stated elevation should be an increasing coefficient with rise of gauge, and the measure of this increase over the coefficient at mean gauge should be the increment of the velocity percentage, as shown by the vertical curve, between the percentage depth of the index at mean gauge and the same percentage depth at a higher gauge.

If this should prove not true, the proposition of fixed velocity ratios would need revision. It may be stated that the observations do not disprove the law of fixed velocity relations at percentages of depth, but that the range of gauge was insufficient to make its reaffirmation very positive. Taking the index at a fixed elevation instead of at a percentage depth is not to be commended in river work, as it involves additional work in the reductions to make other curves comparable.

Having in mind these three different processes—getting a long index measurement, establishing the trend of the vertical curve, and obtaining a relative rating of the instrument—the following programme was arranged:

Open section discharge, vertical—Rating programme.

Station.	Elevation of meter A at index.	Elevations of B meter. Going west. 1	2	3	Going east. 1	2	3	Bottom elevation.	Remarks.
1	566	566	565	564	566	565	564	561.2	Surface elevation for mean of 57 discharges, 566.3.
2	561	565	555	Bottom.	565	561	555	550.6	
3	555	565	555	543	565	543	Bottom.	536.3	
4	553	565	539	Bottom.	565	553	539	531.6	
5	553	565	553	539	565	539	Bottom.	532.3	
6	553	565	539	Bottom.	565	553	539	532.8	
7	553	565	553	539	565	539	Bottom.	532.6	
8	553	565	539	Bottom.	565	553	539	532.3	
9	555	565	555	541	565	541	Bottom.	535.9	
10	555	565	543	Bottom.	565	555	543	536.8	
11	555	565	555	543	565	543	Bottom.	538.4	
12	557	565	547	Bottom.	565	557	547	543.5	
13	557	565	557	549	565	549	Bottom.	545.0	
14	559	565	551	Bottom.	565	559	551	546.9	
15	561	565	561	555	565	555	Bottom.	551.3	
16	561	565	557	Bottom.	565	561	557	553.8	
17	563	565	563	561	565	561	Bottom.	558.5	

When both meters were at the index elevation the run made was a rating observation, and from 388 such runs the contestants for the B meter were derived as shown in rating No. 6, Table 4.

The logical extension of this system is to do all coefficient work and make all ratings of the working meters simultaneous with discharge observations. This is practicable by the use of a third delicately constructed meter, which would be frequently rated on a still-water base, and could be used to standardize the working instruments by daily current comparisons.

The three-meter system of work was recommended in my project of May 16, 1900.

The two-meter method doubled the working capacity of the observing party by adding coefficient work to the regular discharge programme, and was used to advantage in a second form of measurement called a transverse discharge. In this work the meters were suspended from outriggers on each side of the catamaran so that they were 33⅓ feet apart.

The A meter followed its regular program at the index, while the B meter ran simultaneously at the subindex, obtaining the transverse ratio of the west substations, in one discharge observation and those of the east on the return measurement.

In all, 63 complete discharge measurements were made by the two-meter method.

Aside from the fixed points gotten in these, special vertical curve observations were made at each station and at each substation 33⅓ feet away, observing on the odd feet of elevation. In these substation verticals the method used on the bridge section was begun in which the A meter runs at the station index while the B meter transverses the substation vertical. This was abandoned, however, and the A meter was set at the subindex (at the same elevation as the index) while the B meter traversed the same vertical. In this way the current fluctuations were more surely present in both meters.

The transverse discharge noted above completed the connection between the substation vertical and the index. In getting out coefficients, however, these substation verticals were not utilized for two reasons: First, the fixed points in the station verticals made their weight so great in comparison with those of the substations that it was difficult to arrive at a rational scheme of combining them; second, the absence of current ratings as a basis for correcting the ratios made the indications of the compound instrument somewhat unreliable, so that the danger of introducing an error seemed greater than the possibility of error from neglecting in midriver the transverse curve between stations.

In Stations 1, 2, 3, and 17 the transverse curve was used in coefficient reductions.

In investigating the form of the vertical curves, those of Stations 1 and 17 were set aside as in too shallow water for developing the curve, and the remaining 15 were divided into three sets of five each of as near the same depths as possible.

By dividing the discharge observations with all the high gauges in one group and all the low-gauge measurements in the other, and taking for each group the mean of the eight-tenths depth ratios, a percentage was derived for each mean stage, high and low. A similar treatment of the velocity ratios at the subsurface depth, 565, gave likewise two ratios.

Taken in connection with the index, through which both curves must pass at ratio 1.00, the high-gauge curve was defined by three points and the low by three points. The difference in the areas of the two curves divided by the depth indicated the extent of the variation of the coefficient.

This matter will be taken up again later in a discussion of vertical curves in the light of the added high-water observations of 1900, and it may be stated now that the eight-tenths depth ratio showed little change for change of gauge, the mean change in fifteen curves for a gauge movement of 1 foot being but a tenth of 1 per cent. At 565 the change amounted to an increase of 1.2 per cent as the mean of the 15 station curves.

The following summary shows the distribution of the ratio change:

Series number.	Number of observations.	Mean depth.	Stations in series.	Increment in ratio for feet rise in section gauge.	Add to coefficient on this account for feet rise in gauge.
				Per cent.	*Per cent.*
1	95	34	4, 5, 6, 7, 8	2.14	0.4
2	91	28	3, 9, 10, 11, 12	1.36	.3
3	83	17	2, 13, 14, 15, 16	.06	.0
Total	269		15		
Mean		26.3		1.2	.2

A second increment to the coefficient for rise of gauge is due to the excess of the top feet percentage over the mean.

Had the index been located at a percentage of depth instead of at an invariable elevation, the error of constant coefficient for the mean velocity percentage of each series would have been as follows:

INDICATED ERROR OF ASSUMPTION OF CONSTANT VELOCITY.

Coefficient when index is taken at percentage depth.—For 1 foot rise of gauge: Series 1, constant coefficient would be 0.3 per cent too small; series 2, constant coefficient would be 0.3 per cent too small; series 3, constant coefficient would be 0.0 per cent too small.

Mean of 15 curves gives coefficient 0.2 per cent too small, which is almost a negligible quantity. And so far as these observations go they tend to prove the proposition of fixed velocity relations at tenths of depth.

An indication is given that a strong downstream wind speeds the upper strata more than those near the mid-depth, causing a slight reverse flexure to the vertical curve as it nears the surface. Two to three per cent marks the extent of this departure from the curve of calm weather.

It is hoped in the later discussion of vertical curves to follow up the effects of the air perimeter on the variation of the velocities between the index and the surface in upstream and downstream windstorms.

The indications thus far are that the resistance of the air on a calm day to the flow is nearly zero, and that a gale has an astonishingly small effect. The retardation of

the velocities by the drag on the bottom amounts to about 50 per cent of the maximum velocity, while at the surface the still-air resistance is so small that 1 to 2 per cent appears to cover it.

The utility of getting for all conditions of wind and gauge the trend of each station vertical, by the discharge-vertical method of work, in order to interpret correctly the volume of flow, is so great, and it is obtained at so little expense of time, while the index meter is engaged in its discharge measurement, that it is proposed to extend it, so as to cover all points in the vertical curve in subsequent work, by taking the 0, 2, 6, 8, and 10 tenths depth in the discharge measurement and the 1, 3, 5, 7, and 9 tenths in the alternate discharge, thus eliminating all other vertical curve work, just as the current ratings will eliminate all other ratings of the working meters. In this way the discharge measurements go on without interruption for other work and become an omnibus observation for all velocity data necessary for the computation of volume of flow.

The strong points on the verticals, obtained by many repetitions in these observations, are indicated on the platted curves by solid black circles, and the curve is drawn through them. Between them a smooth curve was drawn, as indicated by the open circles representing the percentage velocities of other depths as obtained from the special vertical observations. The mean percentage velocity, as derived from this platted curve, was taken as the mean gauge velocity coefficient.

The coefficients for the various stations are given, together with cross-sectional areas, in Table 6, page 5346.

Measurements back of the terminal cribs were made by floats at two different gauge heights, and from these tables of discharge constructed from which the volumes for any gauge height were taken.

At high gauge the sum of these volumes equaled about 230 cubic feet.

In order to know at all times the exact level of the water surface in the open section, what have been called "long-range" gauges were set up on each of the terminal cribs. These consisted of a clock face about 3 feet in diameter, graduated into ten equal divisions by alternate fields of black and white, and each of these was toothed on the outer circumference into ten smaller divisions, making the whole circle graduated into a hundred parts. A hand traversed this circle, making a complete revolution for a change of a foot in the water level.

The travel of the hand was therefore ten times that of the water, and gave the subdivisions of the foot so that at mid-river both gauges could be read by field glasses to within a hundredth of a foot. A board gauge gave the corresponding even foot of sea-level elevation.

The mechanism of the long-range gauge was exceedingly simple. The hand was set (with a friction adjustment for correcting) on a double-pivoted bearing hard wood spool. The rim of this spool was grooved by a screw thread so that exactly a foot of copper wire No. 23 made a complete turn. The wire led to a copper-sealed iron-kettle float in a box attached to the crib below the gauge face. As the float lifted with rise of water the wire was held taut and spooled by a counterpoising weight on a cord reeled on a smaller part of the spool.

The box inclosing the float was sealed, and water was admitted by two or three half-inch auger holes. This eliminated the dancing of the float when waves were running.

The readings of the hands were tested daily by bottle staffs, similar to those used on the earlier gauges on this river.

It was found that the reading of these gauges was within a hundredth or so that of the Austin street automatic gauge, and that gauge was therefore used as the basis of reductions of soundings and areas.

Each of the reels on the catamaran was equipped with a graduated movable band reading to tenths of a foot. This was set at the reading of the long-range gauge when the meter axis was at the water surface, and reset for each change in gauge of a tenth. The sea-level elevation of the meter at any depth was indicated by this band, in connection with a rider that was advanced along a scale by a screw thread cut in the crank shaft. The rider reflected the approximate position, within two-tenths of a foot, of the meter, while the band gave the exact elevation. This was corrected for curvature of cable in swift water.

In the bridge section, prior to the installment of the Austin street gauge, a box-and-bottle gauge was read for section area. This consisted of a sealed box, perforated with small auger holes, in which floated a 2-quart bottle rigidly attached to a 7-foot staff of $\frac{7}{8}$-inch square pine, shellacked. This staff was graduated to hundredths, so that it gave an increasing reading for rise of gauge, and water level was given by adding the staff reading to the gauge index, minus 7.

The box was about 7 feet long, and 5 inches on the inside, and was made of $\frac{7}{8}$-inch pine boards. The pine cover let the staff through its center, and the elevation of its top as determined by levels from a known bench mark was taken as the index of the gauge.

This form of gauge was used by the Board of Engineers in the slope and discharge work done by them here, and is a simple and accurate device for getting the static head of rough water.

For the fall of 1898 box gauges were read at ten-minute intervals during discharge work for both section and lake elevations, and since that time have been in use as reference gauges to determine the zeros of the automatic gauges.

The two automatic gauges Nos. 11 and 12, the former for lake elevation and the latter for slope and section gauge, were designed by Mr. E. E. Haskell, United States assistant engineer in charge of the Lake Survey work.

This gauge works on a large scale, and not only traces the rise and fall of the water, but graduates the paper it uses, thus coordinating the water-level curve with the time and elevation lines that interpret it.

The advantage of this in accuracy and in economy of maintenance is manifest.

A brass cylinder 15 inches long, driven by a clock centering on its axis, is provided with projecting needle points that engage at each edge a continuous length of paper and pass the paper uniformly over the cylinder, drawing it from its original roll on one side and reeling it up on the other.

A second clock at right angles with the first marks on the paper at each edge the even hours. A fixed pencil traces on the paper as it passes over the cylinder a datum or zero line. The stage pencil is mounted on a carriage that travels, as the water rises and falls, back and forth lengthwise of the cylinder, drawn by a sprocket band of phosphor bronze. The sprocket wheel is on the same shaft with a wheel on the rim of which a V groove is spirally cut to receive several turns of slender phosphor-bronze wire. This wire leads down to a copper float in a 9-inch wrought-iron pipe, and is held taut by a counterpoise carried by a spool on the universal ball-bearing shaft.

The pipe is capped at the bottom, and its only inlet is a $\frac{3}{8}$-inch hole well toward its bottom. For the lake gauge this pipe is fastened to the cribbing of the light-house and protected from ice by 12-inch square timbers. Its length is 16 feet.

At Austin street the pipe is let through the dock floor. A 3-foot column of kerosene oil in the pipe prevents serious trouble from ice formation, and is retained as a mode of repressing the growth of water vegetation in the pipe during the summer.

In extreme cold weather a scale of ice will sometimes form under this, but is of short life, melting as the weather moderates and tending to break with change of gauge.

The automatic or self-registering gauge is equipped with three groved wheels corresponding to 1, $1\frac{1}{2}$, and 3 inches to the foot as scales for the stage pencil. In the lake gauge the middle wheel is used and at No. 12 the wheel for the 3-inch scale.

The time scale is 2 inches to the hour, which makes the daily record 4 feet long. Enough paper is put on the gauge at once to last a month.

The operation of the gauges has been very satisfactory, and the accuracy of the record is unquestionable.

The location of gauge No. 11, to record Lake Erie level, at the light crib at the northwest end of the breakwater, well out in the lake, where it is clear of shore influences, should give elevations at all times representative of the level at this end of the lake.

It is somewhat difficult of approach when the harbor is full of cake ice in early winter and spring, but its clear record is worth the trouble of maintaining it.

Gauge inspections were made semiweekly, to wind the clocks and keep them adjusted to standard time, to spool up the reeling weight, to keep pencils sharp, and to check the zero of the gauge.

For No. 12 a box gauge attached to the gauge house sufficed to keep the datum pencil at the even feet. This box gauge had its index checked by frequent levels from a fixed bench mark on the masonry of the office building of the smelting works,

The zero of the lake gauge depended on water leveling from a box gauge set on the cribbing near the light at the entrance to the inner harbor. In winter the bottle was used without a box, but in an open frame, as the ice absorbed all wave motion, and a box was hard to keep unfrozen.

This reference gauge by which the zero of the automatic gauge depended was connected by levels with U. S. B. M. No. 1, which is a lump on the water table of the light-house just to the right as one comes out of the door. The elevation of this was taken as 589.807.

The gauge is about 200 feet from it.

The zero of a gauge is so important that the dates of the levels by which it was checked are given, as follows:

March 21, 1899.
June 2, 1899.
July 8, 1899.
November 21, 1899.
January 16, 1900.
June 22, 1900.

At each semiweekly inspection of the lake gauge ten readings at intervals of two and a half minutes were made on the reference gauge, constituting a determination of the elevation of the datum or zero line marked by the fixed pencil on the gauge sheet.

This gave a new value every few days for the zero elevation, ranging two to three hundredths of a foot either side of a mean line.

These changes represented the error of the water-level transfer, the effect of sharpening the gauge pencils, the friction in the gauge, the temperature effect on the float wire (in the lake gauge about 30 feet long), and the expansion and shrinkage of the paper in moist and dry air.

These compensating errors were thrown out by many transfers. The elevation of the zero line was taken as variable from day to day by interpolating between the values derived from the semiweekly determinations.

The office work on the sheets was considerable. The stage, zero, and hour lines were inked in, corrections being applied to the last for rate of striking clock. The hours, from 1 to 24, the zero elevation, the scale, the name and location of the gauge, etc., were stamped on each day's record. The daily mean was taken as the sum of half the midnight ordinates, plus the sum of the 23 hourly ordinates, divided by 24. The long monthly sheet was finally folded into a folio, which presented each day's record as a double page.

Over three-fourths of a mile of gauge sheets have been treated in this way.

Table 7 gives the daily and monthly means for the lake gauge and the monthly means for the Austin street gauge.

An investigation showed that a high-water crest appeared on the lower gauge about ten minutes later than on the lake gauge. This lag varied somewhat with stage, but was taken as a uniform time correction between cause and effect in the height of the lake gauge and the resulting velocities on the open section. No time correction for this was applied on the bridge section.

As the gauge varied during the time of a discharge measurement, a mean must be taken as representing the lake stage which produced the particular outflow. A simple arithmetical mean would not give a proper value for the generating head in all cases. When the gauge was high while the unimportant stations were being measured and low for the stations of great volume, the discharge would be considerably different than when the high and low water were reversed at these stations, the mean gauge height being the same. This consideration led to the use of a weighted mean gauge, in which the weights for the several stations were proportional to the discharge in each.

The slope for each discharge given in Tables 8 and 9 are therefore differences of these weighted means.

TABLE 7.—*Summary of daily and monthly mean elevations of Lake Erie at breakwater, Gauge 11; also monthly means for elevation at Gauge 12 and fall between 11 and 12.*

Day of month.	1899. Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	1900. Jan.	Feb.	Mar.	Apr.	May.	June.
1	571.17	572.22	571.81	572.31	572.07	572.00	571.63	571.32	571.05	571.80	572.02	571.80	*a* 570.90	571.74	572.01	572.01
2	571.03	*a* 571.96	571.85	572.24	572.12	572.26	571.59	570.95	570.46	572.00	573.08	571.40	*a* 572.00	571.67	571.99	572.48
3	571.11	*a* 571.78	*a* 571.43	572.15	*a* 572.03	572.09	571.83	571.14	570.88	571.11	571.39	571.09	571.79	571.74	572.09	572.26
4	570.90	571.68	571.60	572.23	*a* 572.05	572.12	571.34	571.23	572.41	571.30	571.28	570.81	571.29	571.80	572.14	572.10
5	571.98	571.64	571.90	572.26	572.05	571.98	571.90	571.12	571.52	572.71	571.42	571.15	570.85	571.93	572.04	572.11
6	571.24	571.54	571.91	572.37	*a* 572.20	571.88	571.40	571.13	571.38	571.88	570.99	571.10	571.99	571.84	571.97	572.08
7	571.21	*a* 571.44	571.86	572.28	*a* 572.15	*a* 571.84	571.58	570.80	571.32	571.90	571.44	570.93	571.74	571.81	571.77	572.21
8	571.49	571.89	571.91	572.51	572.60	*a* 571.85	571.59	570.97	571.25	571.36	570.98	570.98	571.40	571.79	572.09	572.25
9	571.41	571.86	571.93	572.32	572.37	571.78	571.51	571.35	571.61	570.78	570.93	571.90	571.46	571.82	572.10	572.18
10	571.14	571.67	571.85	572.12	572.22	571.97	571.45	571.25	571.33	571.24	571.12	571.07	571.54	571.83	572.15	572.09
11	571.44	571.60	572.18	572.11	572.21	571.92	571.83	571.27	570.97	571.13	570.50	571.11	571.19	571.25	572.06	572.25
12	572.00	571.78	571.99	572.23	572.25	572.15	571.95	571.18	571.21	572.80	571.26	571.05	571.43	571.98	572.00	571.96
13	571.58	571.65	572.17	572.25	572.05	571.86	571.68	571.17	571.21	572.00	*a* 570.92	572.04	571.61	571.88	572.18	572.08
14	570.85	571.86	572.09	572.33	572.14	571.34	571.49	571.23	571.08	570.59	*a* 571.08	571.52	571.53	572.15	572.17	572.26
15	571.98	571.88	571.99	572.41	572.13	571.34	571.38	570.99	571.63	571.69	*a* 570.92	571.55	571.14	571.81	572.20	572.06
16	571.50	571.89	571.93	572.45	572.35	571.68	571.43	571.20	570.99	571.12	571.11	571.33	571.59	571.62	571.73	572.03
17	571.12	571.69	571.75	572.29	572.30	571.76	571.51	571.37	571.22	571.46	570.74	571.31	572.24	571.69	572.04	572.04
18	571.26	571.66	572.24	572.26	572.46	571.78	571.56	571.43	571.45	571.19	571.10	571.36	571.45	571.97	571.96	571.84
19	571.82	*a* 571.72	572.40	572.20	572.18	571.78	571.22	571.24	571.52	571.69	571.06	571.29	571.55	572.23	571.94	571.98
20	572.16	571.69	572.26	572.41	572.15	571.79	571.43	571.06	571.19	571.84	571.13	571.12	571.96	571.85	572.13	572.05
21	*a* 570.85	571.70	572.14	572.20	572.32	572.03	571.82	570.97	571.23	571.73	571.32	570.88	571.65	571.83	572.19	572.08
22	571.39	571.69	572.04	572.06	571.83	572.01	571.74	571.25	571.19	571.42	571.41	571.35	571.56	571.91	572.16	571.89
23	572.79	571.60	572.04	572.33	571.82	571.76	571.13	571.37	570.55	571.16	571.40	571.63	571.55	571.98	572.03	571.79
24	571.96	571.79	572.01	572.19	571.86	571.74	571.74	571.35	571.12	572.19	570.93	572.10	571.48	571.94	571.99	571.98
25	571.38	571.83	572.08	572.22	572.08	571.74	571.73	571.27	571.16	572.34	571.60	572.35	570.99	571.93	571.97	572.08
26	571.77	571.82	572.09	572.11	572.19	571.49	571.37	571.32	571.25	572.02	572.25	571.41	571.49	572.01	571.98	572.08
27	571.50	571.73	572.21	572.17	572.25	571.57	572.01	571.09	571.27	571.90	571.58	571.25	571.80	572.07	571.99	572.33
28	571.73	571.80	572.17	571.85	572.03	571.38	572.05	571.31	571.59	571.98	572.15	*a* 571.03	571.65	572.01	571.96	572.28
29	573.22	571.79	572.26	571.76	572.29	571.56	571.54	571.56	571.47	571.50	571.91	....	571.47	571.97	571.88	572.42
30	571.75	571.78	572.49	*a* 572.10	572.24	571.63	571.86	571.18	571.34	571.60	571.93	....	571.34	572.10	572.08	572.36
31	571.72	....	572.21	....	572.03	571.68	....	570.81	....	572.23	571.82	....	571.71	....	572.17	....
Monthly mean	571.56	571.75	572.03	572.22	572.16	571.80	571.61	571.19	571.26	571.67	571.38	571.32	571.53	571.87	572.04	572.12
Monthly mean section gauge	566.55	566.56	566.84	567.06	567.12	566.93	566.73	566.33	566.31	566.58	566.82	566.97	566.81	566.74	566.95	566.96
Fall, Gauge 11 to 12	5.01	5.19	5.19	5.16	5.04	4.87	4.88	4.86	4.95	5.09	4.56	4.35	4.72	5.13	5.09	5.16

a Indicates that elevation for day, or for larger part of day, has been derived from Gauge 12 by slope correction owing to incomplete record of lake gauge. These should be taken plus or minus 0.10 foot.

TABLE NO. 8.—*Bridge section—Summary of discharge observations.*

Reference number of measurement.	Date of measurement.	Current meter used at index.	Rating number. (See Table 4.)	Elevation of water surface above mean tide, New York.		River fall, lake to bridge.	Change of lake level during measurement.		Wind.		Volume of discharge in cubic feet per second.
				Lake Erie level.	At bridge.		Rise.	Fall.	Direction from which blows.	Approximate velocity, miles per hour.	
	1898.										
5	Sept. 10	L. S. 2 b	1	571.16	566.73	4.43	0.02	0.23	NE.	8	180,560
6	13	do	1	571.74	567.12	4.62	0.06	0.22	SW.	6	195,810
7	13	do	1	571.67	567.09	4.58	0.00	0.21	SW.	6	194,970
8	15	do	1	571.72	567.14	4.58	0.07	0.11	SW.	9	195,540
9	15	do	1	571.87	567.18	4.69	0.44	0.02	SW.	9	198,940
10	17	do	1	571.45	566.95	4.50	0.06	0.15	SW.	6	188,500
11	17	do	1	571.46	566.92	4.54	0.18	0.06	SW.	7	190,360
12	20	do	1	571.67	567.01	4.66	0.13	0.20	NW.	5	195,050
13	20	do	1	571.50	566.96	4.54	0.15	0.06	NE.	5	191,290
14	22	do	1	571.41	566.94	4.47	0.02	0.12	SW.	10	189,080
15	22	do	1	571.48	566.89	4.59	0.25	0.07	SW.	12	191,060
16	24	do	1	571.49	566.84	4.65	0.68	0.10	NE.	6	193,840
17	24	do	1	571.95	567.10	4.85	0.10	0.12	NE.	4	206,560
18	27	do	1	572.06	567.14	4.92	0.10	0.01	NW.	4	206,880
19	27	do	1	572.09	567.24	4.85	0.02	0.12	NW.	6	208,320
20	29	do	1	571.56	566.98	4.58	0.03	0.15	SW.	7	188,940
21	29	do	1	571.44	566.91	4.53	0.04	0.15	SW.	7	187,370
22	Oct. 1	do	1	571.13	566.63	4.50	0.11	0.03	SE.	3	181,930
23	1	do	1	571.19	566.65	4.54	0.22	0.04	SE.	2	184,800
24	4	do	1	571.36	566.82	4.54	0.11	0.20	SE.	3	188,700
25	4	do	1	571.47	566.84	4.63	0.16	0.01	S.	2	190,090
26	6	do	1	571.12	566.64	4.48	0.09	0.09	NE.	6	182,210
27	6	do	1	571.37	566.70	4.67	0.28	0.04	NE.	6	188,030
28	8	do	1	571.43	566.81	4.62	0.13	0.03	N.	5	188,930
29	8	do	1	571.44	566.82	4.62	0.10	0.10	N.	6	188,810
30	11	do	1	572.35	567.70	4.65	0.00	0.74	SW.	18	212,510
31	11	do	1	571.70	567.37	4.33	0.03	0.32	SW.	16	196,850
32	13	do	1	571.28	566.71	4.57	0.12	0.07	E.	5	188,490
33	13	do	1	571.35	566.72	4.63	0.14	0.11	E.	8	190,370
34	15	do	1	571.51	567.02	4.49	0.21	0.02	NW.	8	188,880
35	15	do	1	571.74	567.08	4.66	0.14	0.04	NW.	8	193,470
36	17	do	1	570.85	566.43	4.42	0.03	0.03	SE.	8	183,200
37	17	do	1	570.73	566.34	4.39	0.03	0.16	E.	8	175,590
38	17	do	1	570.50	566.12	4.38	0.04	0.10	SE.	10	173,830
39	17	do	1	570.35	566.05	4.30	0.01	0.22	SE.	10	169,210
40	19	do	1	571.12	566.72	4.40	0.42	0.05	SW.	10	180,150
41	19	do	1	571.32	566.78	4.54	0.02	0.21	SW.	12	184,920
42	21	do	1	571.32	566.79	4.53	0.02	0.23	S.	12	189,720
43	22	do	1	....	568.63	....	......	......	SW.	30	224,460
44	23	do	1	....	567.73	....	......	......	W.	12	194,870
45	25	do	1	571.37	566.84	4.53	0.07	0.06	SW.	10	188,960
46	25	do	1	571.39	566.82	4.57	0.08	0.03	SW.	10	192,180
47	27	do	1	572.03	567.50	4.53	0.46	0.30	NW.	12	201,000
48	27	do	1	572.32	567.57	4.75	0.06	0.13	NW.	12	209,560
49	Nov. 1	do	1	572.00	567.15	4.85	0.00	0.37	SSW.	14	207,120
50	1	do	1	571.68	567.03	4.65	0.16	0.13	SW.	14	195,800
51	2	do	1	571.57	567.12	4.45	0.11	0.02	W.	10	194,940
52	2	do	1	571.54	567.04	4.50	0.07	0.22	W.	12	192,970
53	4	do	1	571.31	566.68	4.63	0.07	0.06	S.	10	187,980
54	4	do	1	571.24	566.65	4.59	0.01	0.23	S.	10	186,890
55	4	do	1	571.18	566.54	4.64	0.12	0.07	S.	8	187,570
56	4	do	1	571.15	566.53	4.62	0.05	0 06	S.	7	185,740
57	9	do	1	569.82	565.72	4.10	0.00	0.46	NE.	8	155,600
58	9	do	1	569.85	565.47	4.38	0.45	0.27	NE.	12	157,240
59	9	do	1	....	565.57	....	.....	......	NE.	10	162,240
60	10	do	1	569.71	565.34	4.37	0.15	0.00	NE.	10	154,060
61	10	do	1	569.74	565.36	4.38	0.07	0.24	ENE.	12	154,500
62	10	do	1	569.95	565.41	4.54	0.67	0.03	ENE	10	161,570
63	15	do	1	....	567.76	....	......	......	SW	20	228.090
64	15	do	1	....	567.97	....	......	......	SW.	20	237,950
65	21	do	1	571.58	566.73	4 85	0.10	0.12	SE.	3	197.140
66	21	do	1	571.36	566.67	4.69	0.00	0.18	SE	4	190.040
67	22	do	1	571 50	566.61	4.89	0.05	0.08	SE.	10	191,670
68	22	do	1	571.37	566.66	4.71	0 02	0.27	SE.	10	193,480
69	23	do	1	572.50	567.57	4.93	0.07	0.06	NW.	8	214,910
70	23	do	1	572.23	567.48	4.75	0.25	0.34	W.	7	208,560
71	26	do	1	571.15	566.45	4.70	0.14	0 02	SE.	10	182,890
72	26	do	1	571.14	566.45	4.69	0 06	0.12	SE.	10	183,510
73	26	do	1	571.45	566.61	4.84	0.09	0 03	NE.	8	192,350
74	28	do	1	571.25	566.53	4 72	0.04	0.04	NW.	5	187,520
75	28	do	1	571.52	566.59	4.93	0 38	0 04	NW.	4	192,550
76	29	do	1	571 17	566.50	4 67	0.05	0.08	SE.	3	188,530
77	29	do	1	571.27	566.53	4.74	0.20	0.10	SE.	3	186,460
78	29	do	1	571.34	566.56	4.78	0.36	0.06	E.	5	188,110

TABLE No. 8.—*Bridge section—Summary of discharge operations*—Continued.

Reference number of measurement.	Date of measurement.	Current meter used at index.	Rating number. (See Table 4.)	Elevation of water surface above mean tide, New York. Lake Erie level.	Elevation of water surface above mean tide, New York. At bridge.	River fall, lake to bridge.	Change of lake level during measurement. Rise.	Change of lake level during measurement. Fall.	Wind. Direction from which blows.	Wind. Approximate velocity, miles per hour.	Volume of discharge in cubic feet per second.
	1898.										
79........	Dec. 1	D. S. 2 b..	1	572.72	567.72	5.00	0.07	0.18	W.	18	221,200
80........	1	....do....	1	572.68	567.71	4.97	0.17	0.15	NW.	20	217,630
81........	1	....do....	1	572.53	567.59	4.94	0.24	0.15	NW.	20	215,190
82........	1	....do....	1	572.40	567.57	4.83	0.12	0.23	W.	20	215,000
83........	6	....do....	1	572.21	567.13	5.08	0.07	0.14	SW.	30	215,580
84........	7	....do....	1	573.40	568.19	5.21	0.04	0.28	W.	20	234,510
85........	7	....do....	1	572.90	568.02	4.88	0.17	0.27	W.	15	222,610
86........	8	....do....	1	572.76	567.77	4.99	0.14	0.05	W.	20	219,370
87........	8	....do....	1	572.71	567.73	4.98	0.04	0.04	W.	20	218,791
88........	10	....do....	1	573.60	568.50	5.10	0.15	0.04	W.	25	238,050
89........	10	....do....	1	573.63	568.49	5.14	0.09	0.15	W.	30	240,910
90........	10	....do....	1	573.41	568.38	5.03	0.15	0.11	W.	30	231,270

TABLE No. 9.—*Open section—Summary of discharge observations.*

Reference No. of measurement.	Date of measurement.	Current meter used at index.	Rating No. (See Table 4.)	Elevations of water surface above mean tide, New York. At gauge 11, breakwater. Lake Erie level.	Elevations of water surface above mean tide, New York. At gauge 12, foot Austin street, at section.	River fall, gauge 11 to gauge 12.	Change of level of lake during measurement. Rise.	Change of level of lake during measurement. Fall.	Wind. Direction from which blows.	Wind. Approximate velocity (miles per hour).	Volume of discharge in cubic feet per second.
	1899.										
1.........	Oct. 4	L-s. 4A...	5	571.37	566.51	4.86	0.02	0.17	N.	5	186,290
2.........	5	....do....	5	571.10	566.28	4.82	0.11	0.02	N.	4	181,940
3.........	6	....do....	5	571.13	566.29	4.84	0.15	0.10	NE.	5	181,570
4.........	6	....do....	5	571.15	566.30	4.85	0.10	0.03	NE.	10	181,370
5.........	7	....do....	5	571.28	566.34	4.94	0.06	0.05	SE.	4	185,390
6.........	7	....do....	5	570.99	566.25	4.74	0.01	0.42	NE.	5-15	176,690
7.........	9	....do....	5	571.49	566.54	4.95	0.21	0.14	SW.	15-8	192,760
8.........	11	....do....	5	571.06	566.29	4.77	0.17	0.22	....	....	181,800
9.........	11	....do....	5	571.31	566.37	4.94	0.26	0.09	SW.	0-8	186,610
10.........	12	....do....	5	571.30	566.41	4.89	0.10	0.20	SW.	5	188,970
11.........	12	....do....	5	571.04	566.29	4.75	0.06	0.16	SW.	4	180,160
12.........	13	....do....	5	571.19	566.31	4.88	0.09	0.04	SW.	6	182,500
13.........	19	....do....	5	571.24	566.35	4.89	0.10	0.22	N.	3-7	183,180
14.........	20	....do....	5	570.91	566.09	4.82	0.05	0.10	....	....	177,700
15.........	20	....do....	5	571.13	566.21	4.92	0.32	0.12	NNE.	3-10	183,100
16.........	21	....do....	5	570.99	566.13	4.86	0.07	0.07	E.	7	179,560
17.........	21	....do....	5	570.98	566.13	4.85	0.09	0.13	NE.	5	179,440
18.........	27	....do....	5	571.12	566.29	4.83	0.14	0.25	E.	4	185,040
19.........	27	....do....	5	571.06	566.24	4.82	0.07	0.15	NE. E.	10-12	183,520
20.........	28	....do....	5	571.20	566.30	4.90	0.33	0.30	SW. SE.	8-2	185,720
21.........	28	....do....	5	571.73	566.59	5.14	0.59	0.09	SW. SSW.	20-14	199,850
22.........	30	....do....	5	571.34	566.41	4.93	0.22	0.11	NE. W.	3-1	190,440
23.........	30	....do....	5	571.28	566.40	4.88	0.04	0.24	NNE.	4	185,410
24.........	31	....do....	5	570.93	566.08	4.85	0.22	0.14	ENE.	4	180,620
25.........	31	....do....	5	570.84	566.04	4.80	0.08	0.16	NE.	4	170,390
26.........	Nov. 1	....do....	5	571.22	566.31	4.91	0.38	0.20	N. NE.	20-15	183,810
27.........	2	....do....	5	570.49	565.77	4.72	0.18	0.27	NE.	10	169,430
28.........	2	....do....	5	570.53	565.72	4.81	0.52	0.21	NE.	8	168,770
29.........	3	....do....	5	570.87	565.90	4.97	0.24	0.27	SSE. ENE.	10-10	175,750
30.........	3	....do....	5	570.38	565.71	4.67	0.04	0.29	ENE.	7	165,230
31.........	4	....do....	5	572.60	567.11	5.49	0.97	0.25	SW.	18-12	216,440
32.........	4	....do....	5	573.00	567.62	5.38	0.11	0.39	W.	20	221,960
33.........	6	....do....	5	571.35	566.43	4.92	0.09	0.07	NW.	2	185,450

TABLE No. 9.—*Open section—Summary of discharge observations*—Continued.

Reference No. of measurement.	Date of measurement.	Current meter used at index.	Rating No. (See Table 4.)	Elevation of water surface above mean tide, New York. At gauge 11, breakwater Lake Erie level.	Elevation of water surface above mean tide, New York. At gauge 12, foot Austin street, at section.	River fall gauge 11 to gauge 12.	Change of level of lake during measurement. Rise.	Change of level of lake during measurement. Fall.	Wind. Direction from which blows.	Wind. Approximate velocity (miles per hour).	Volume of discharge in cubic feet per second.
	1899.										
34	Nov. 7	L-s. 4A	5	571.27	566.37	4.90	0.15	0.15	NW. W.	½–5	184,160
35	11	do	5	571.19	566.20	4.99	0.05	0.38	ENE.	10	181,680
36	11	do	5	570.88	566.08	4.80	0.54	0.23			174,400
37	23	do	5	570.44	565.67	4.77	0.15	0.34	NE.	8	167,540
38	23	do	5	570.25	565.53	4.72	0.14	0.10	ENE. E.	8–10	165,340
39	24	do	5	571.03	566.07	4.96	0.21	0.12	NE.	1	182,680
40	24	do	5	571.16	566.17	4.99	0.14	0.05	NE. NW.	3–4	185,540
41	25	do	5	571.14	566.20	4.94	0.03	0.19	NE. N.	3–4	182,160
42	25	do	5	571.01	566.11	4.90	0.15	0.05	NW.	5	181,870
43	27	do	5	571.27	566.23	5.04	0.28	0.02	SW.	2	188,410
44	27	do	5	571.43	566.37	5.06	0.15	0.04	SW. W.	5	191,850
45	28	do	5	571.68	566.54	5.14	0.22	0.05	SW.	12	194,470
46	28	do	5	571.59	566.54	5.05	0.11	0.20	SW.	18	193,270
47	29	do	5	571.46	566.39	5.07	0.26	0.02	W.	2	190,200
48	29	do	5	571.39	566.42	4.97	0.13	0.39	SW.	10	188,660
49	Dec. 2	do	6	572.34	567.05	5.29	0.14	0.29	SW.	20	209,390
50	2	do	6	572.12	566.85	5.27	1.68	0.04	SW.	20–30	208,750
51	4	do	6	571.16	566.14	5.02	0.23	0.06	W. NW.	2–5	184,040
52	4	do	6	571.44	566.34	5.10	0.05	0.04	NW.	6–1½	190,610
53	5	do	6	571.54	566.71	4.83	0.54	0.70	WNW.	6	188,370
54	6	do	6	571.88	567.00	4.88	0.16	0.30	WNW.	20	195,560
55	6	do	6	571.42	566.55	4.87	0.14	0.61	NW.	10	186,160
56	9	do	6	570.59	565.74	4.85	0.41	0.26	E.	7	170,080
57	9	do	6	570.63	565.70	4.93	0.21	0.03	E.	8	170,870
	1900.										
58	June 28	do	6	572.44	567.19	5.25	0.88	0.12	SW.	10–30	217,970
59	28	do	6	572.75	567.49	5.26	0.08	0.55	SW.	35	220,590
60	29	do	6	573.12	567.59	5.53	1.02	0.05	SW.	15–40	231,350
61	29	do	6	572.65	567.69	4.96	0.06	0.96	NW.	40–45	216,040
62	30	do	6	572.60	567.37	5.23	0.61	0.49	NW. W.	12–30	217,240
63	30	do	6	572.66	567.51	5.15	0.31	0.30	W. NW.	20–35	216,060

The falls given in Table 7 between the two automatic gauges have been platted with respect to lake elevation showing the seasonal cycle of the monthly means. Other things being the same, each lake stage should be accompanied by a given outflow and river slope.

Both tend to increase for higher stages, but as the weeds grow down the river the water is backed up by the greater resistance and hence the steeper slope below cuts down the slope from section to lake. In January, February, and March the decreased slope is doubtless due to the lodgment of ice in the lower river shallows above the rapids leading to the falls.

Ice masses that grounded in 8 feet of water and were anchored for weeks were not infrequent on the open section ends. Some days, with a fair lake stage, the fall dropped down below 4 feet.

It is probable that at such times the discharge is diminished as much as 10 per cent, and these natural dams that tend to conserve the winter flow must be reckoned with in the problem of lake levels.

The weed effect on the discharge is probably small.

The measure of these retarding influences on the outflow is reserved for future discussion. With the long field seasons and short office time, it has been found impracticable to investigate much outside of the normal conditions of flow. Even in these, more observations on both sections are reserved (together with the July, 1900, work on the open section) for a future report.

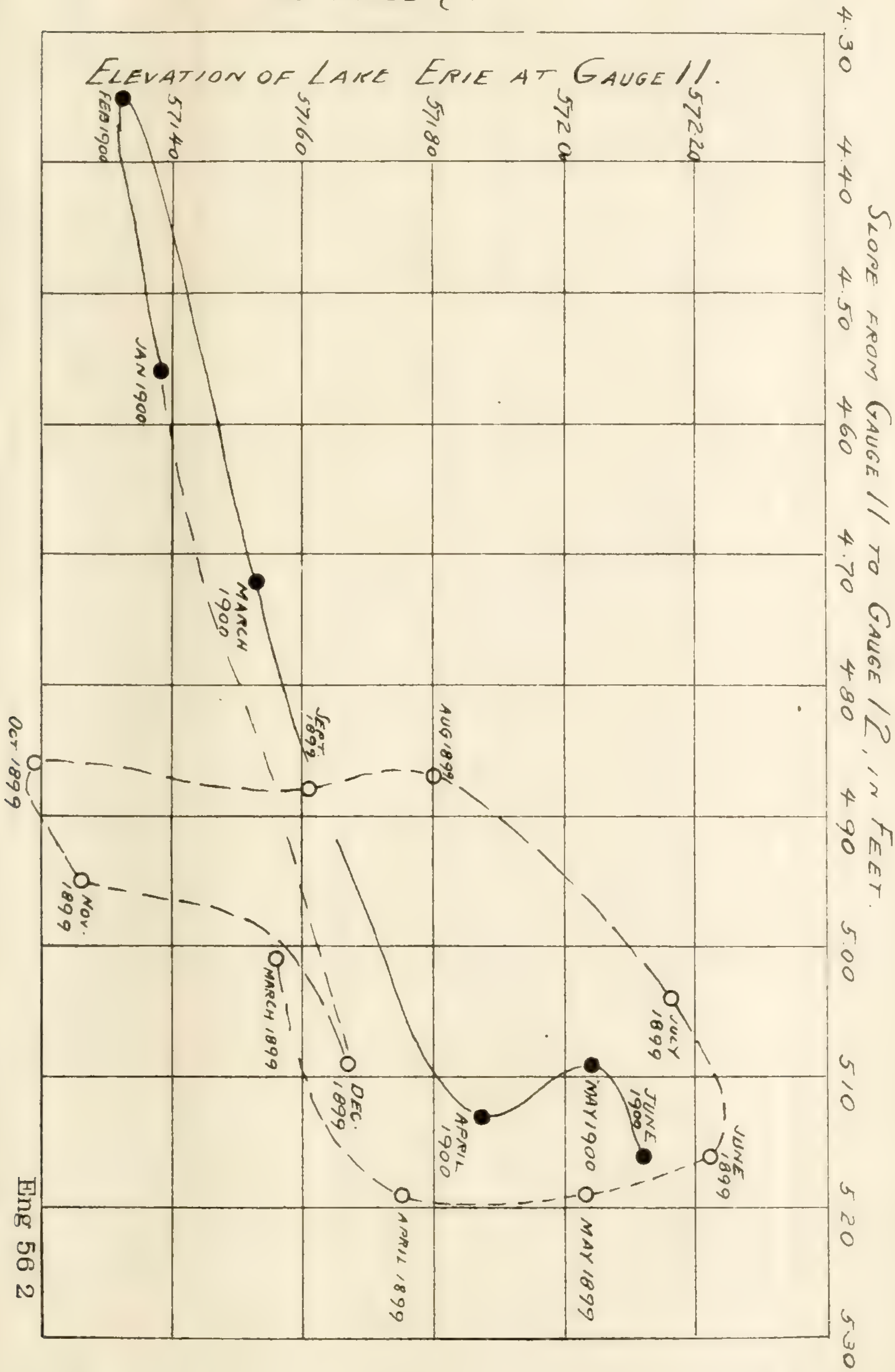
DISCHARGE OF NIAGARA RIVER.

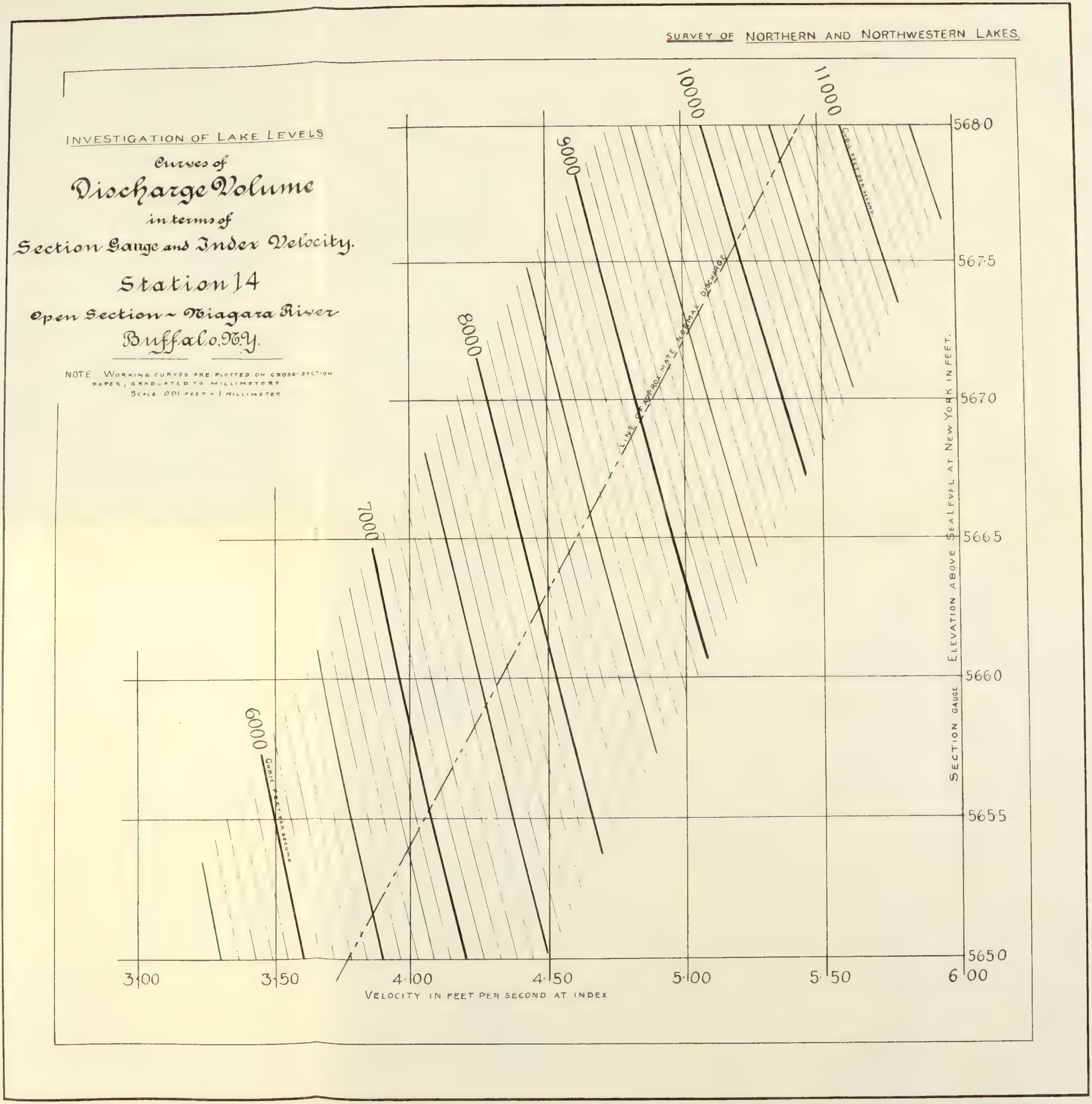
THE SEASONAL SLOPE CYCLE

BETWEEN LAKE GAUGE No. 11 AND SECTION GAUGE No. 12

PROBABLY DUE TO GROWTH OF AQUATIC WEEDS IN LOWER RIVER IN SUMMER AND ICE IN WINTER

SEE TABLE 7.




SURVEY OF NORTHERN AND NORTHWESTERN LAKES.
INVESTIGATION OF LAKE LEVELS
Curves of
Discharge Volume
in terms of
Section Gauge and Index Velocity.
Station 14
Open Section ~ Niagara River
Buffalo, N.Y.
NOTE Working curves are plotted on cross-section paper, graduated to millimeters. Scale .001 feet = 1 millimeter
6000
Cubic feet per second
7000
8000
9000
10000
11000
Cubic feet per second
Line of approximate normal discharge
568·0
567·5
567·0
566·5
566·0
565·5
565·0
Section gauge Elevation above sea level at New York in feet.
3·00
3·50
4·00
4·50
5·00
5·50
6·00
Velocity in feet per second at index

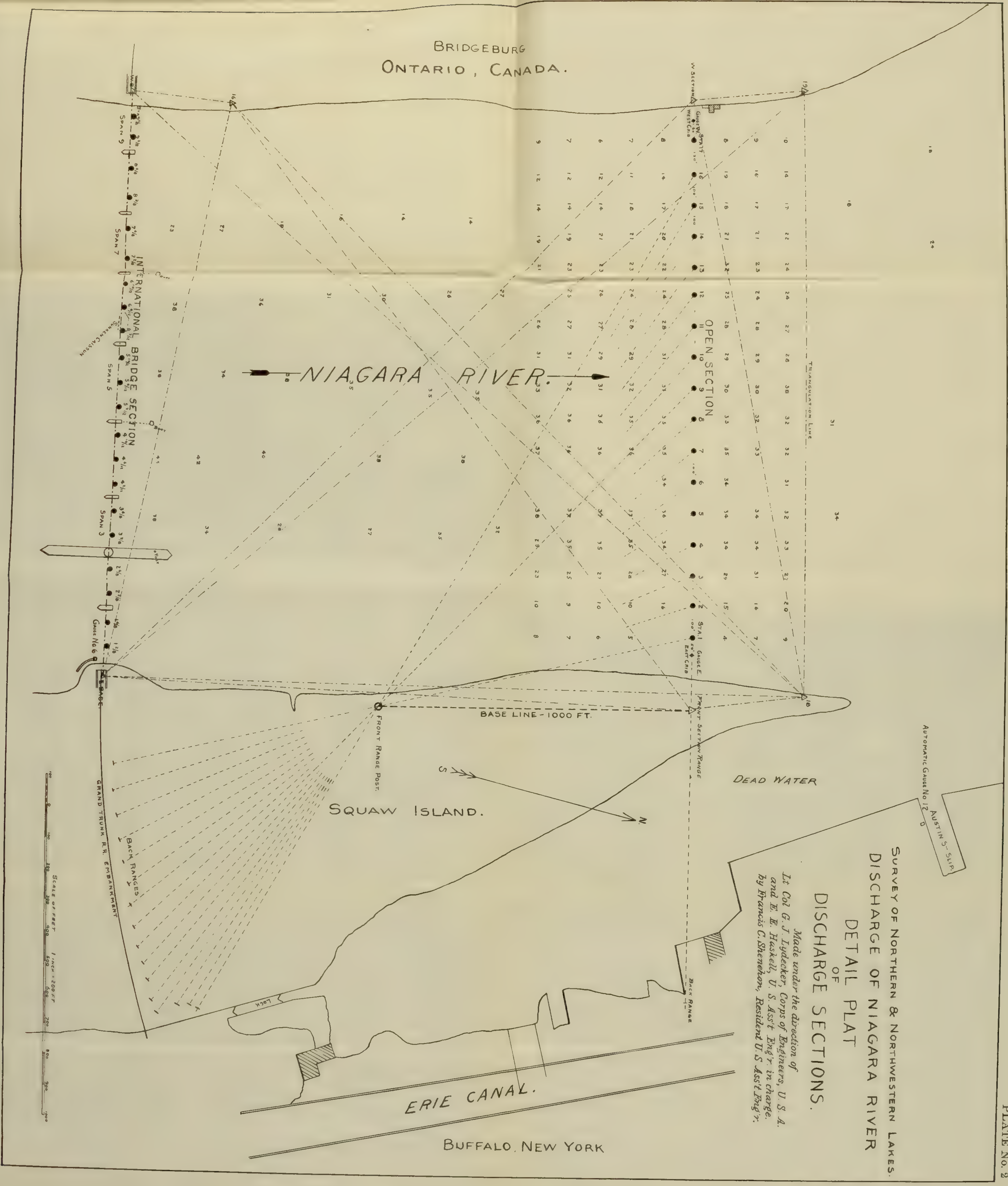
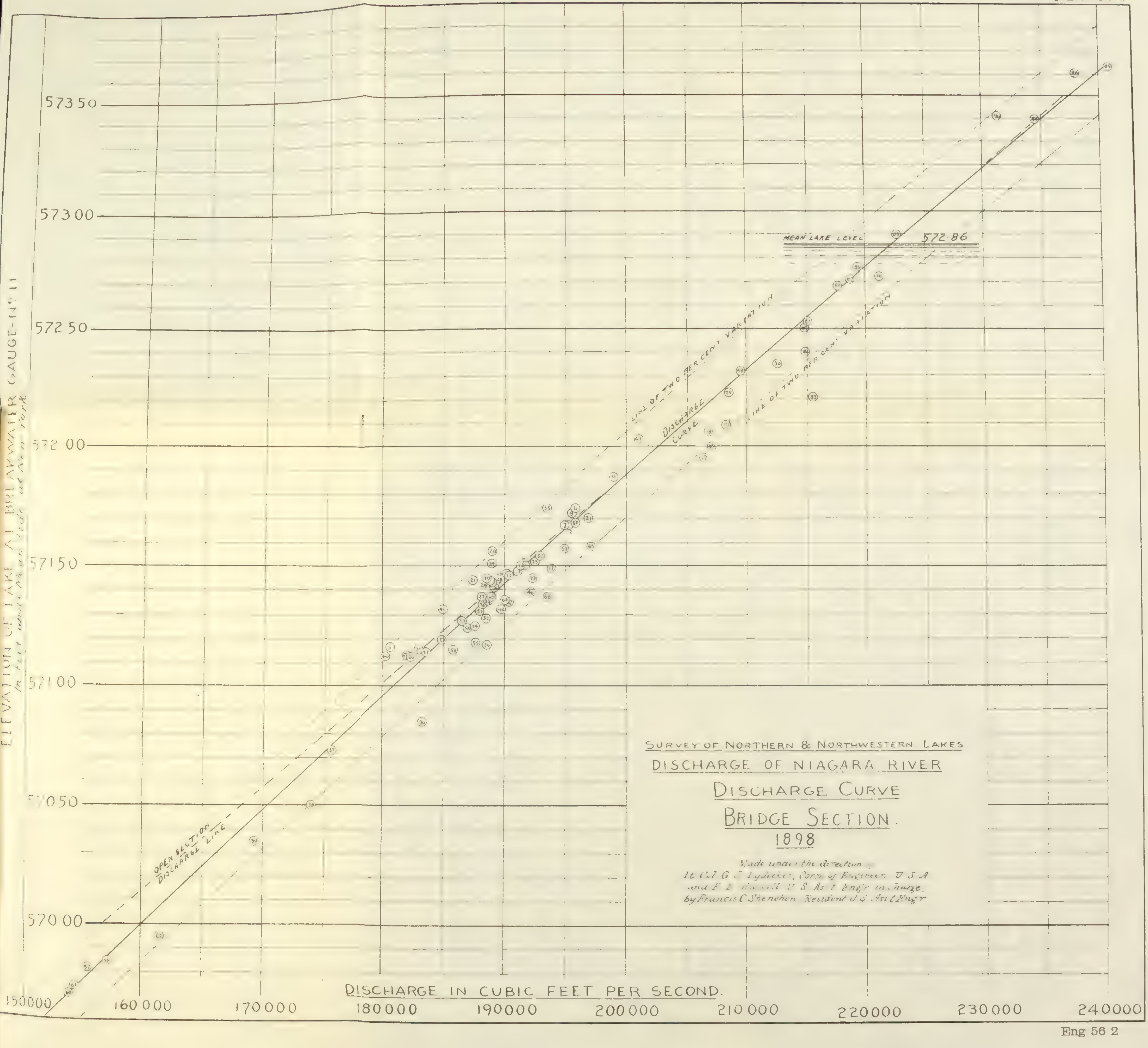
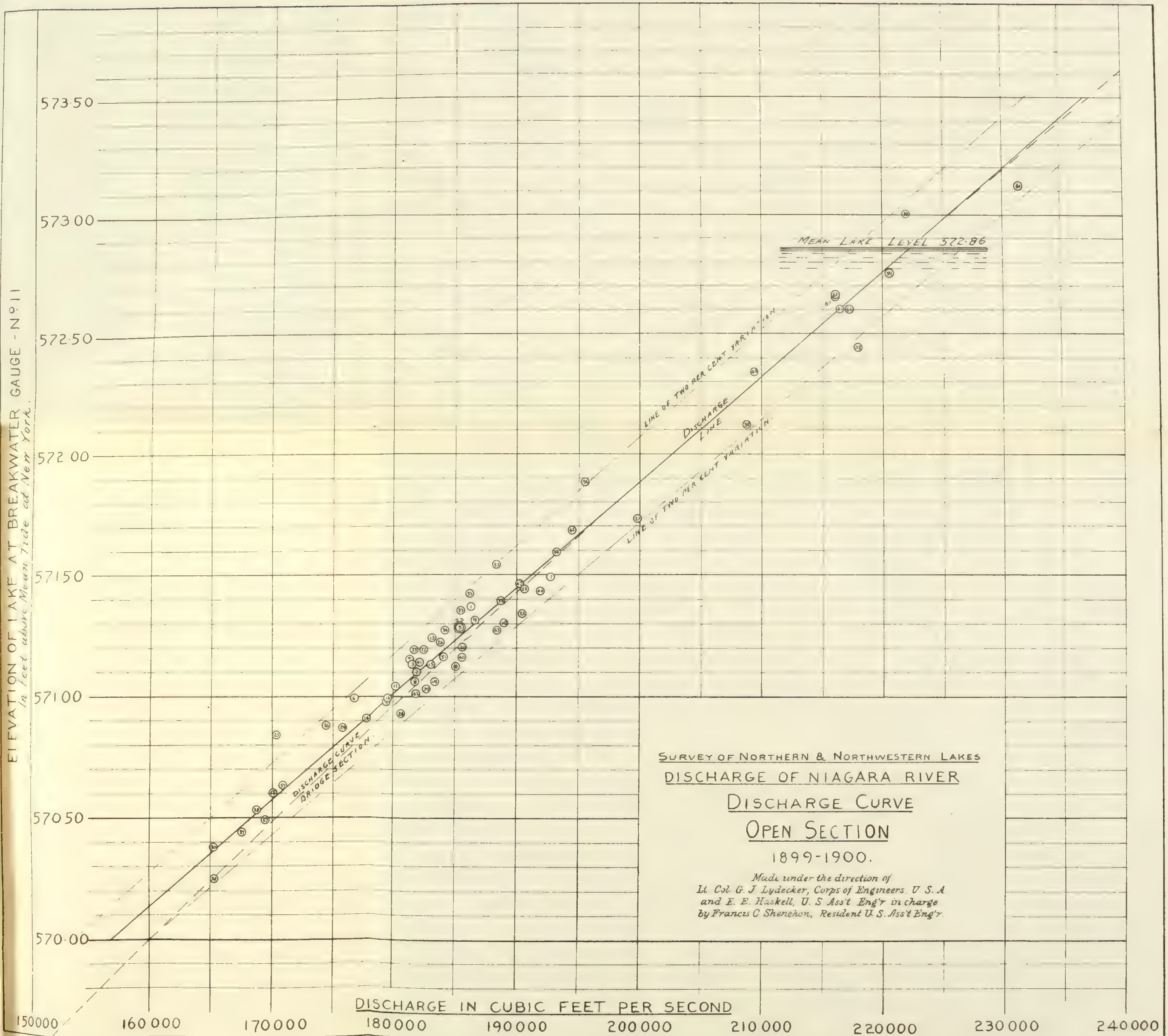


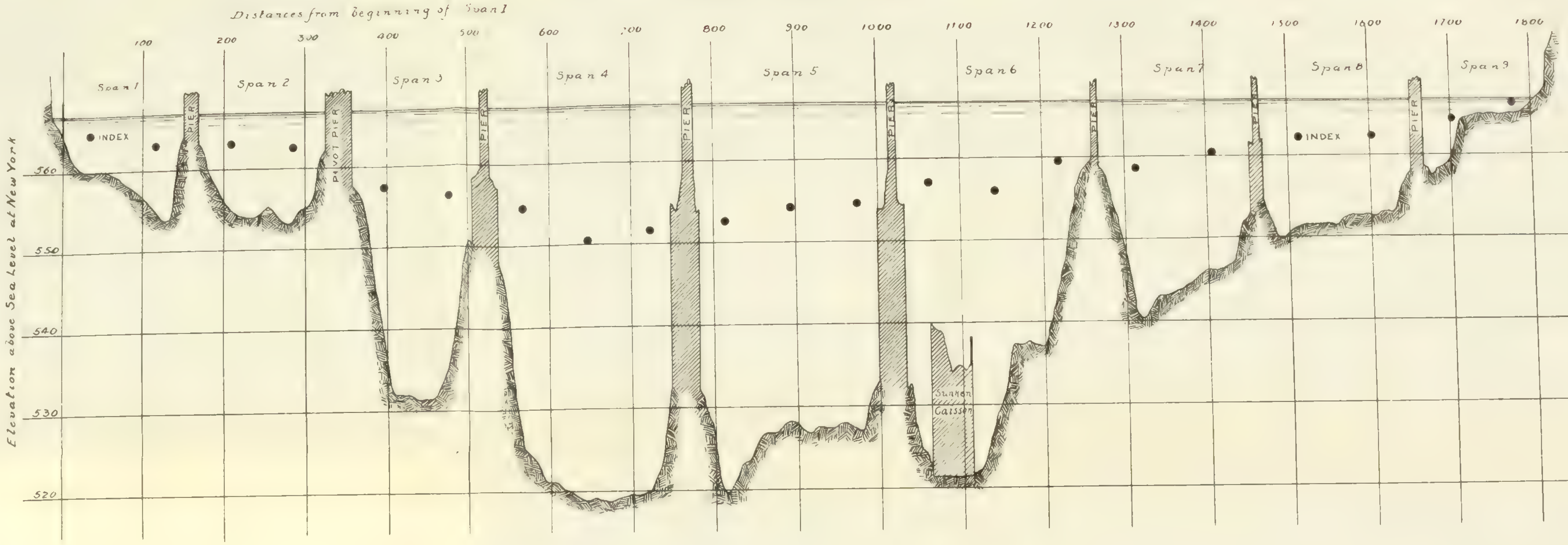
PLATE No. 2

Eng 56 2

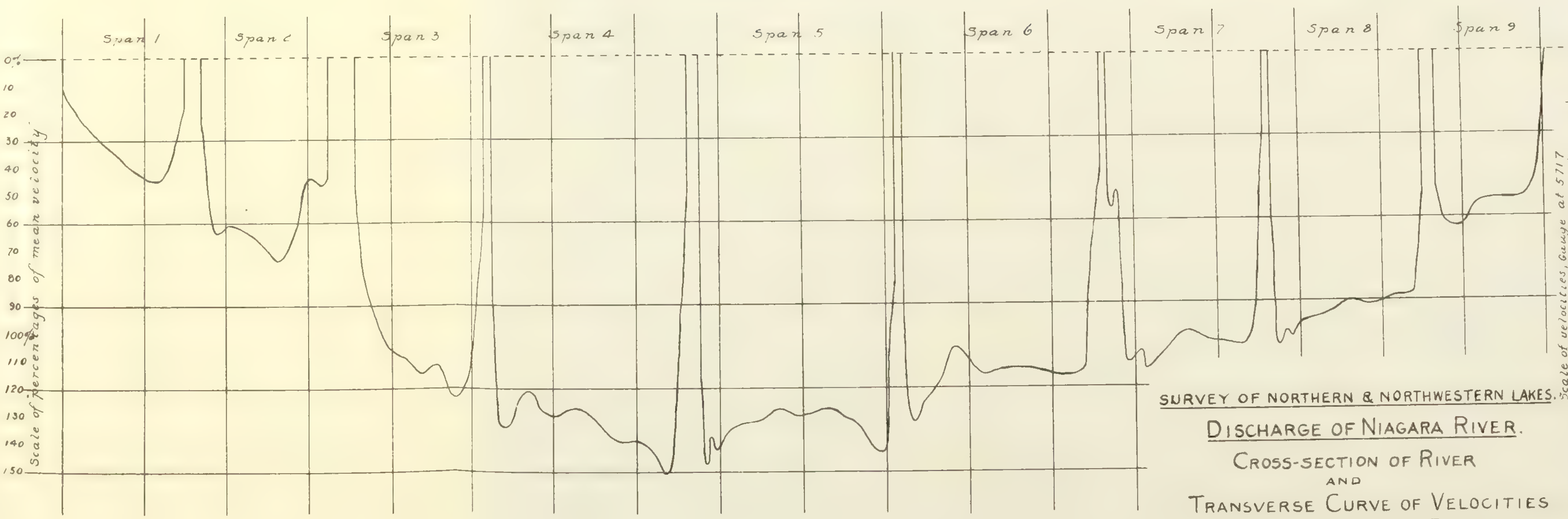

SURVEY OF NORTHERN & NORTHWESTERN LAKES
DISCHARGE OF NIAGARA RIVER
DISCHARGE CURVE
BRIDGE SECTION.
1898
ELEVATION OF LAKE AT BREAKWATER GAUGE-No 11
573 50
573 00
572 50
572 00
571 50
571 00
570 50
570 00
150000
160 000
170000
180000
190000
200000
210 000
220000
230000
240000
DISCHARGE IN CUBIC FEET PER SECOND.
MEAN LAKE LEVEL
572.86
LINE OF TWO PER CENT VARIATION
DISCHARGE CURVE
LINE OF TWO PER CENT VARIATION
OPEN SECTION DISCHARGE LINE


ELEVATION OF LAKE AT BREAKWATER GAUGE - No. 11
In feet above Mean Tide at New York.
573.50
573.00
572.50
572.00
571.50
571.00
570.50
570.00
DISCHARGE IN CUBIC FEET PER SECOND
150000
160000
170000
180000
190000
200000
210000
220000
230000
240000
MEAN LAKE LEVEL 572.86
LINE OF TWO PER CENT VARIATION
DISCHARGE LINE
LINE OF TWO PER CENT VARIATION
DISCHARGE CURVE BRIDGE SECTION
SURVEY OF NORTHERN & NORTHWESTERN LAKES
DISCHARGE OF NIAGARA RIVER
DISCHARGE CURVE
OPEN SECTION
1899-1900.
Made under the direction of
Lt. Col. G. J. Lydecker, Corps of Engineers, U. S. A.
and E. E. Haskell, U. S. Ass't Eng'r in charge
by Francis C. Shenehon, Resident U. S. Ass't Eng'r.

CROSS-SECTION.



CURVE OF VELOCITIES AT 3/10 DEPTH.



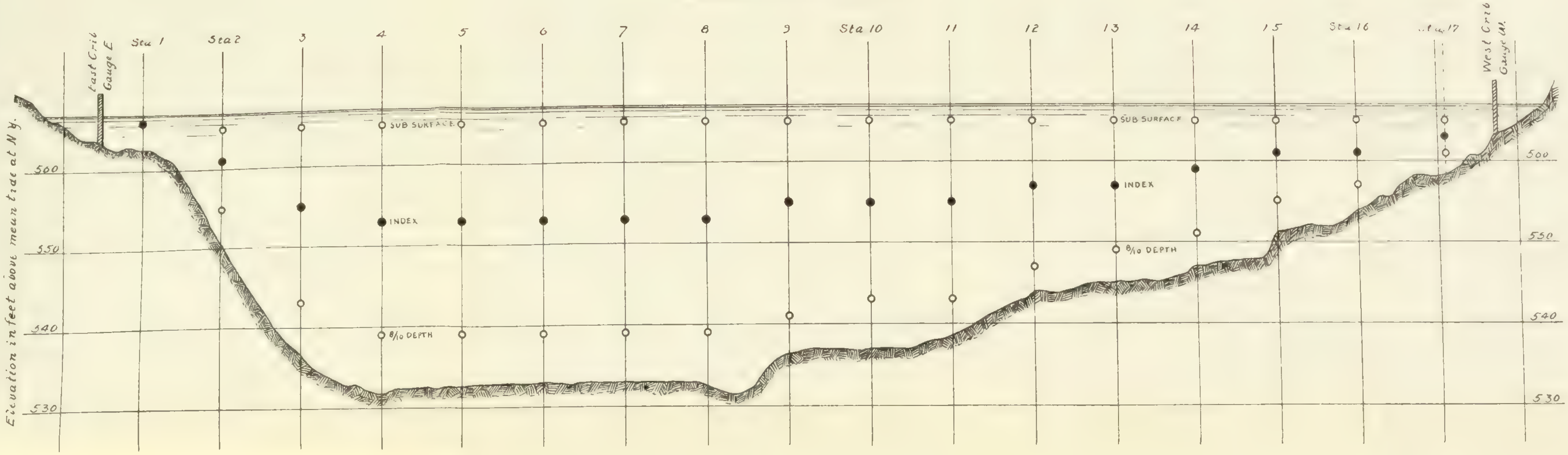
SURVEY OF NORTHERN & NORTHWESTERN LAKES.

DISCHARGE OF NIAGARA RIVER.

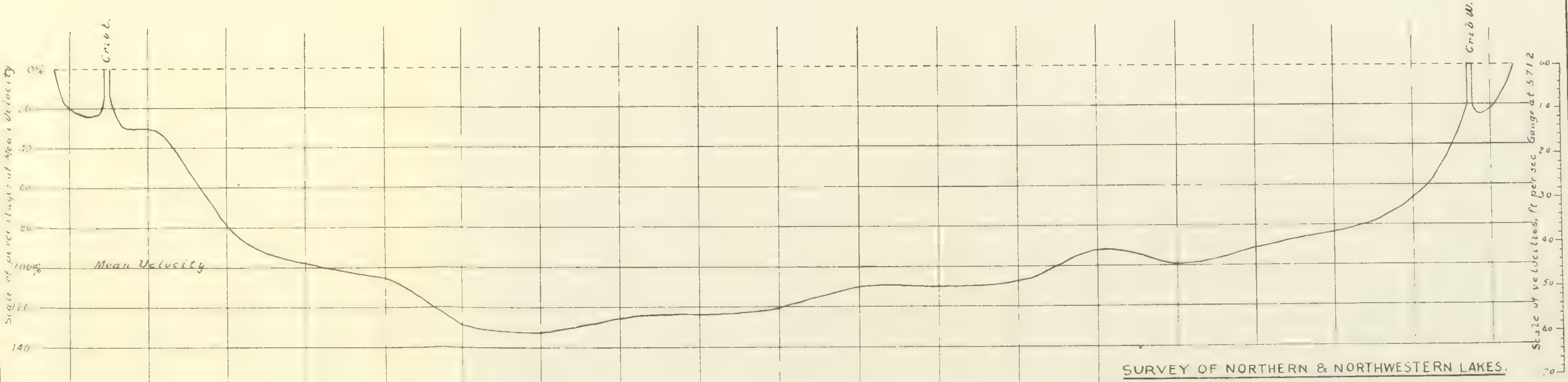
CROSS-SECTION OF RIVER
AND
TRANSVERSE CURVE OF VELOCITIES
AT INTERNATIONAL BRIDGE.

Made under the direction of
Lt. Col. G. J. Lydecker, Corps of Engineers, U. S. A.
and E. E. Haskell, U. S. Ass't. Eng'r. in charge.
by Francis C Shenehon, Resident U.S Ass't Eng'r.

CROSS-SECTION.



CURVE OF VELOCITIES AT 4/10 DEPTH.



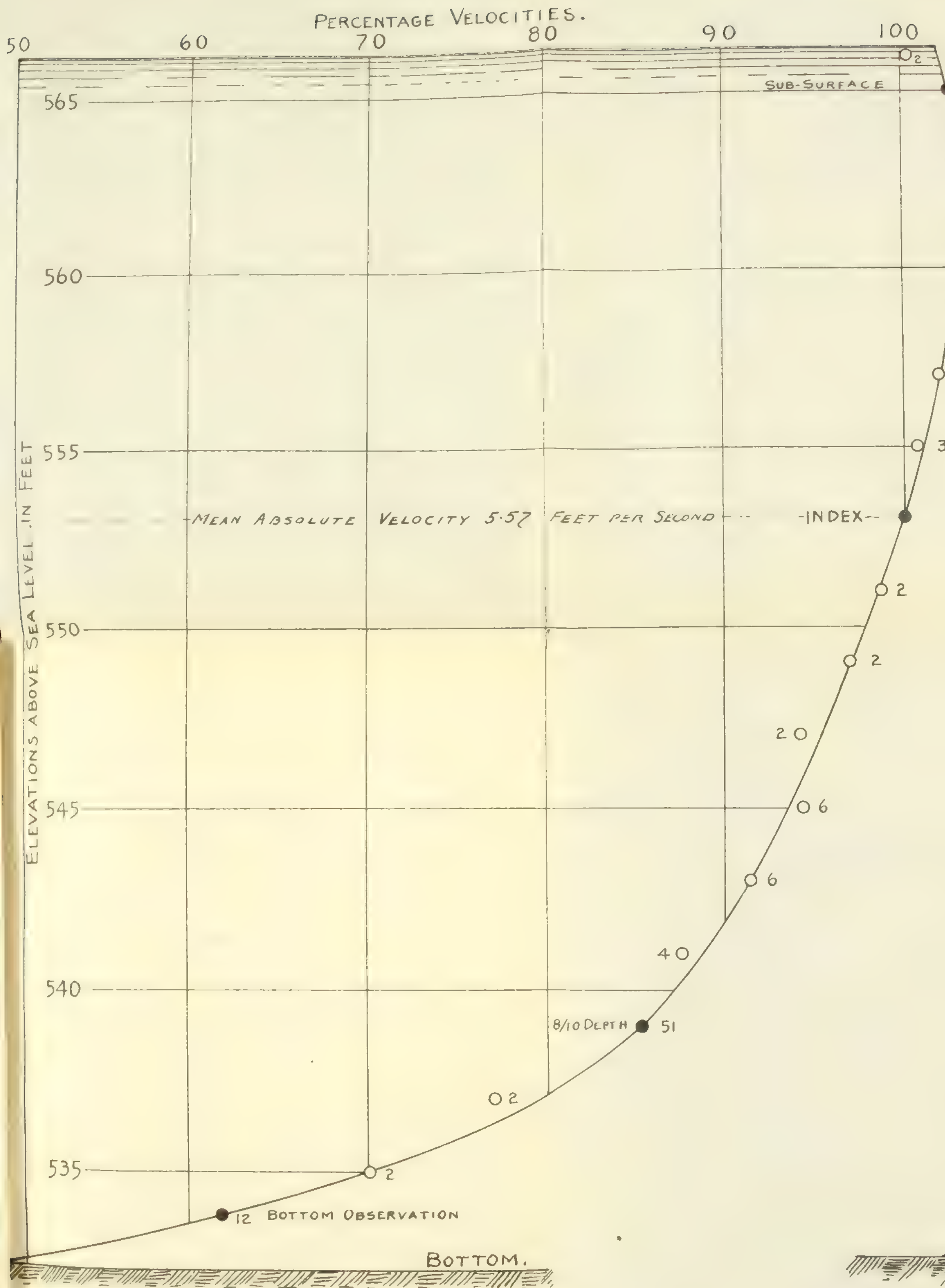
SURVEY OF NORTHERN & NORTHWESTERN LAKES.

DISCHARGE OF NIAGARA RIVER.

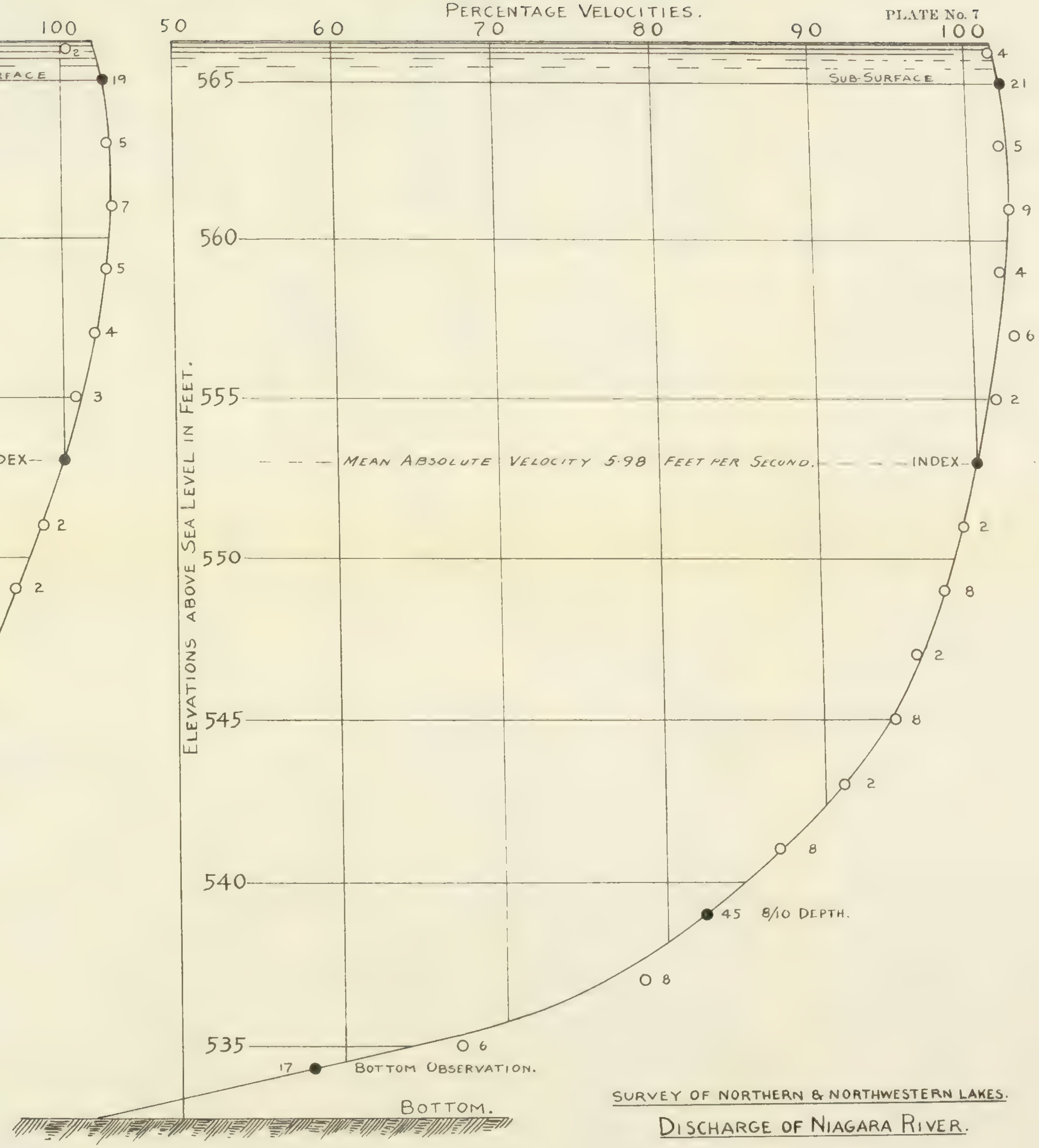
CROSS-SECTION OF RIVER
AND
TRANSVERSE CURVE OF VELOCITIES
ON OPEN SECTION.

Made under the direction of
Lt Col G. J Lydecker, Corps of Engineers, U. S. A
and E. E. Haskell, U. S. Ass't Eng'r. in charge
by Francis C. Shenehon, Resident U. S. Ass't Eng'r.

PLATE No. 7



STATION 8.



STATION 6.

SURVEY OF NORTHERN & NORTHWESTERN LAKES.

DISCHARGE OF NIAGARA RIVER.

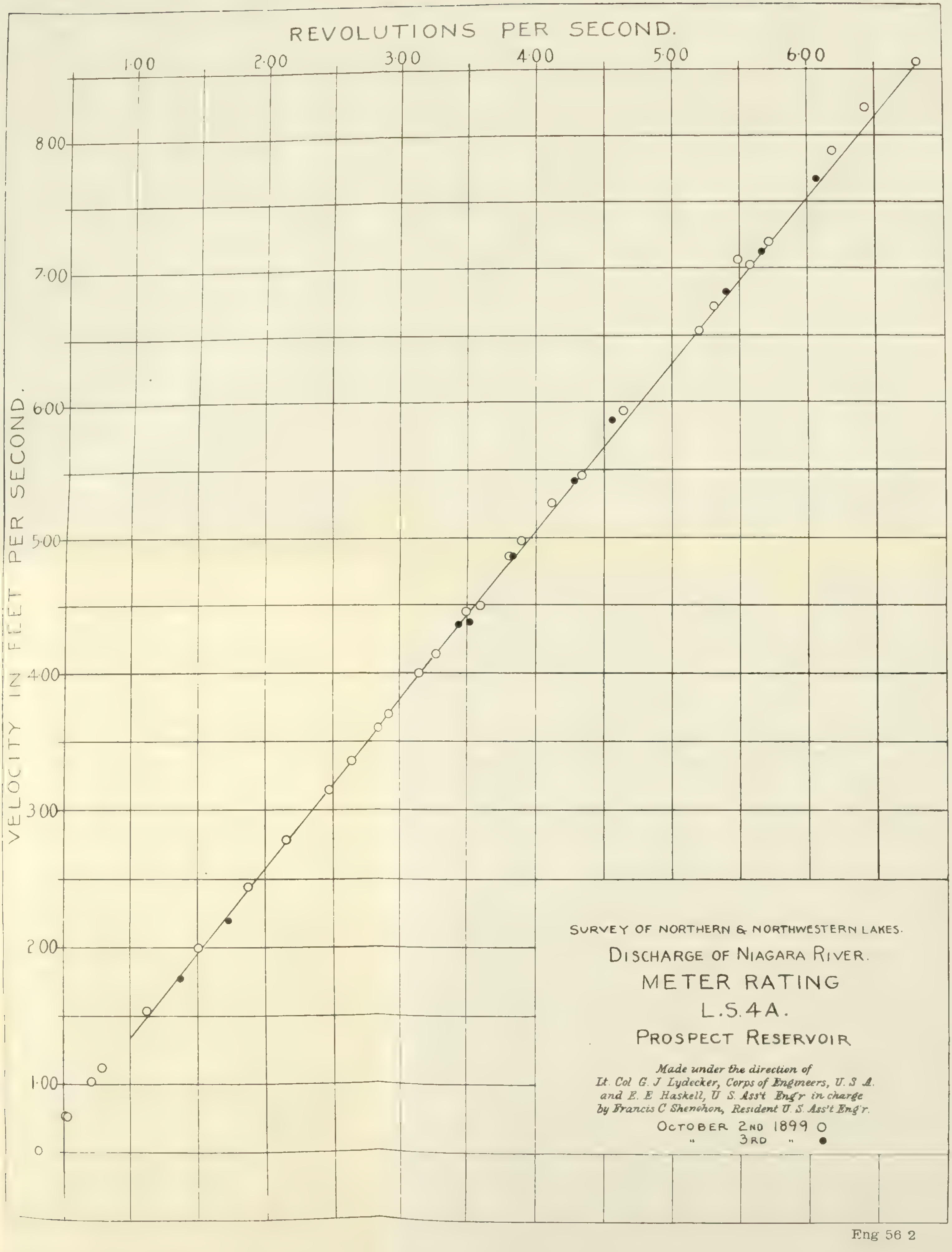
TYPICAL VERTICAL CURVES.

OPEN SECTION.

Made under the direction of
Lt Col G J Lydecker, Corps of Engineers, U. S. A
and E. E. Haskell, U S. Ass't. Eng'r. in charge.
by Francis C Shenehon, Resident U. S Ass't Eng'r.

Note: Numbers opposite circles indicate by how many observations each point was determined. Solid circles indicate points fixed by Discharge Verticals.

Eng 56 2


REVOLUTIONS PER SECOND.
1·00
2·00
3·00
4·00
5·00
6·00
VELOCITY IN FEET PER SECOND.
8·00
7·00
6·00
5·00
4·00
3·00
2·00
1·00
0
SURVEY OF NORTHERN & NORTHWESTERN LAKES.
DISCHARGE OF NIAGARA RIVER.
METER RATING
L.S.4A.
PROSPECT RESERVOIR
Made under the direction of
Lt. Col. G. J. Lydecker, Corps of Engineers, U. S. A.
and E. E. Haskell, U. S. Ass't Eng'r in charge
by Francis C. Shenehon, Resident U. S. Ass't Eng'r.
OCTOBER 2ND 1899 ○
" 3RD " ●

Tables 8 and 9 summarize the observations now reported.

These are platted in the two discharge curves, and lines representing the approximate laws of discharge are drawn in.

Treatment by the method of least squares is hardly warranted at this time, with more observations at hand that will affect in small measure the coefficients of the open section and will add much to the strength of the upper part of the line.

No decided curvature is shown in the open section, and little in the bridge section.

The following summary gives the discharge in cubic feet per second:

Elevation of lake gauge.	Discharge, open section.	Increment for 0.1-foot rise.	Discharge, bridge section.	Increment for 0.1-foot rise.
573.5			237,500	
				2,380
573.0	225,500		225,600	
		2,300		2,320
572.5	214,000		214,000	
		2,280		2,260
572.0	202,600		202,700	
		2,280		2,220
571.5	191,200		191,600	
		2,280		2,160
571.0	179,800		180,800	
		2,280		2,100
570.5	168,400		170,300	
		2,280		2,060
570.0	157,000		160,000	

At mean lake level, 572.86, the discharge for both sections is 222,400.

It is exceedingly satisfactory to be able to report so close a check in the results of the measurements of the two sections.

The sections are very different, and received different methods of treatment.

The bridge-section index velocities depend on the B meter and the Detroit rating of this instrument, by an excellent observer.

The open-section velocities depend on the A meter, rated on the Buffalo base, by different methods and by different observers.

The bridge measurements were in 1898; those of the open section in 1899 and 1900.

The former was from a fixed structure, the latter from a survey boat, whose influence on the current lines might be a factor in the result.

The coefficient work has some elements common to both, especially the rating of the traveling meter.

Yet it will be seen by a reference to the relative ratings of Table 4 that the coefficients would not be appreciably changed by using any other established rating for the traveling meter. The coefficients in both sections have been established by overwhelming numbers of observations, by accurate methods, and were derived by different methods of reduction.

Having a splendid equipment, the entire work has been carried out with careful attention to fundamental principles and to details, and with the infinite patience demanded in catching the many moods of this great river.

If the results are suspiciously good, they are the true interpretation of the notes as I see them, without juggling.

Throughout the whole of this work the bulk of the instrumental work in the execution of the observations programmes has devolved on my chief assistant, Recorder H. F. Johnson, and I desire to express my appreciation of his field management and to acknowledge my indebtedness to him, not alone in this, but in many suggestions that have bettered and helped along the work.

Working both on the bridge section and on the open section on the stormiest days, when laborers have quit work and sought shelter, my party has ungrumblingly faced wind and rain, snow and cold, to catch the flow for high lake crests. To this interest in the results, that extended to all members of the party, and made a gale welcome, is to be credited the great numbers and gauge range of our observations, and the reflection of all wind and weather conditions shown in them.

Back of the party here, the courtesy of both the executive and the clerical departments of the headquarters office has contributed to the efficiency of the force.

The cordial approval of the new departures in river work, as recommended by me, has been unfailing, and to this willingness to leave old beaten tracks and build new ones the results achieved are to be largely credited.

Very respectfully,

Francis C. Shenehon,
Assistant Engineer.

Mr. E. E. Haskell, *Assistant Engineer.*

REPORT OF MR. L. C. SABIN, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Port Huron, Mich., July 1, 1900.

SIR: I have the honor to submit the following report on the determination of the discharge of St. Clair River and the slope in channels connecting lakes Huron and Erie:

The conditions prevailing at the outlet of Lake Huron differ from those at Superior and Erie in that the transition from lake to river is very abrupt. Just above Fort Gratiot Light-House, which we may consider the head of the river, the channel is about 4,000 feet wide, and a half mile above this the lake has a width of some 7,000 feet. Below the light-house the shores converge rapidly, the most restricted cross section, only 800 feet in width, being found about a half mile below. Through this reach the river has naturally scoured out a deep channel, making a very effective cross section, but yet one that requires a high velocity on account of the restricted width. About 6,000 feet below the light-house the river becomes much wider and forms a middle ground, the main channel following the Canadian shore. Three miles below the head the river assumes a width of 2,000 feet which is, in a general way, maintained for a distance of 24 miles, to the head of the delta at Roberts Landing. From here the waters reach Lake St. Clair through several branches, the main ones being the north and south channels. The latter, used for navigation at present, terminates in the St. Clair Flats Canal, the foot of which is 41 miles below Port Huron. The distance across Lake St. Clair is 17 miles, measured along the navigable channel, and the Detroit River, connecting lakes St. Clair and Erie, is about 27 miles in length.

In this report the work will be considered in the following order:

First. A brief account of the survey of the head of St. Clair River, including a description of the discharge section and the locations of water gauges.

Second. The method of rating meters and of computing the rating equations with a summary of the equations used.

Third. The method of observing for "vertical curves," the reduction of the observations and a summary of the results.

Fourth. A brief discussion of the fluctuations in water level and of current velocity.

Fifth. The method of measuring the discharge and of reducing the observations.

Sixth. The derived relation of discharge and lake stage and the modifying effect of the wind.

Seventh. Discharge observations by integration method and the distribution of velocities in the cross section.

Eighth. The slope at the head of St. Clair River.

Ninth. The fall from Lake Huron to Lake Erie, a study of its seasonal and yearly changes and a comparison of past and present conditions.

Tenth. The effect on the level of Lake Michigan-Huron of withdrawing a fixed amount through an independent outlet.

SURVEY OF THE HEAD OF ST. CLAIR RIVER.

The hydrographic survey of the river has been carried from Lake Huron to Stag Island, the work being prosecuted at such times as other operations would permit. The shoals at the mouth of Black River and at the head of Stag Island were sounded in 1898 by Assistant Engineer Haskell, and the present surveys have been joined to these.

In connection with the survey of 1898 a short base was measured on the American side just below Black River. In 1899 a check base was laid out along the water-works park front and measured with steel tape No. 2. Posts 2 by 4 inches were driven along the line at intervals of 100 feet and cut off to grade. A small brad was driven in line in the top of each post. Tape supports were provided at 25-foot intervals, a wire nail being driven horizontally at grade in the side of a 2 by 2 inch post. A tension of 16 pounds was applied to the tape by spring balance. The rear end of tape was fastened to a lever, hinged at the bottom to a foot block on which the rear chain man stood. By grasping the upper end of the lever the chain man held the rear end of tape even with south side of brad in rear stake. At the forward end a spring balance connected the forward end of the tape with a similar lever operated by the head chain man. When rear-end graduation was in correct position, the rear observer called, "Read," and the recorder at forward end repeated this if spring balance indicated 16 pounds; the observer at forward end then read, on a celluloid scale, the distance of the 0.2-foot graduation of the tape from the south side of brad in forward stake. This was recorded with the thermometer reading taken at the same time, the thermometer U. S. L. S. No. 1 being at the middle point of the 100-foot tape. This operation repeated three times constituted one observation, and the

base was measured twice, forward and back. The length of base was approximately 2,200 feet; the time occupied in the two measurements was two hours. The difference in length by the two measurements was 0.004 foot.

The locality was covered by a small triangle system. Angles were read with a Buff & Berger 10-second transit, readings being taken around the horizon from left to right with telescope normal and repeated from right to left with telescope inverted. The length of the base measured in 1898 as given by the triangulation carried down from the head of the river was 0.08 foot greater than the measured length, an accidentally close agreement. The length of the line, △ "Head of Stag Island" to △ "Locust," differed by 1.3 feet from the length as carried up from a base line below the island in 1898.

Soundings.—Most of the soundings were taken from the Lake Survey Tug No. 2, soundings being located by transit intersections from triangulation stations. The sounding leads used were of 10 and 12 pounds weight. The lead line was of ¼-inch braided cotton sash cord with leather tags at 10-foot marks, red cloth at 5-foot marks, and black thread lashings at the foot marks. The sounding line was tested daily at beginning and end of work. In rapid currents and deep water two leadsmen were required, one casting the lead near the bow and the other taking the depth at the starboard beam. The transit observers were signaled by short blasts of the whistle, and time comparisons were carefully made identifying pairs of readings. Samples of the bottom were obtained by means of a conical cup covered with a movable cap of sole leather. The cup was fastened to the bottom of an iron rod having an eye at the top. A 17-pound conical lead was made in two parts. The upper half was attached to the rod just below the eye, while the lower half slid freely on the rod, having a play of about 1½ inches between the cup and the upper lead. The sole-leather cap was about 1 inch larger in diameter than the cup. The weight of the upper lead settled the cup in the bottom, while the lower lead held the leather cap in place when bringing up the sample. The device was not satisfactory in a hard gravel bottom, though it worked fairly well in clay or sand.

A map showing the shore line and hydrography as determined by this survey has already been transmitted. Plate I herewith shows the shore line and gauge locations, bottom contours, etc.

TABLE No. 1.—*Characteristics of St. Clair River from Fort Gratiot Light-House to discharge section.*

Section number.	Distance along channel from point opposite Fort Gratiot Light-House.	Area.	Width.	Mean depth.	Maximum depth.	Section number.	Distance along channel from point opposite Fort Gratiot Light-House.	Area.	Width.	Mean depth.	Maximum depth.
	Feet.	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*		*Feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*
0	0	96,400	3,850	25.0	60.0	10	8,900	43,000	1,120	38.4	50.0
1	800	61,100	2,050	29.8	76.0	11	9,900	50,900	1,540	33.0	50.0
2	1,200	46,800	1,420	33.0	73.0	12	11,600	59,500	2,600	22.9	36.0
3	2,150	35,800	1,020	35.0	65.0	13	13,900	64,900	2,680	24.2	40.0
4	3,200	35,000	800	43.7	65.0	14	16,500	60,300	2,350	25.7	43.0
5	3,800	36,800	940	39.2	49.0	15	18,400	56,500	1,870	30.2	41.0
6	4,200	40,000	1,132	35.3	43.0	16	20,900	54,800	1,750	31.3	46.0
7	4,700	41,900	1,300	32.2	43.0	17	23,400	60,000	2,000	30.0	40.0
8	6,200	44,700	1,500	29.8	48.0	18	25,300	56,500	2,050	27.6	34.0
9	7,400	41,500	1,300	31.9	54.0	19	27,500	59,800	2,120	28.2	36.0

Cross sections of river.—In December, 1898, a cross section at the "gorge," where the river is but 800 feet in width, was carefully sounded, and this was repeated in the fall of 1899, when three other sections at the head were also carefully determined by taking soundings over them several times. These four sections are marked by iron gas-pipe stakes, so that they may be laid out and sounded again at any time to test the permanence of the regimen. The sections marked are "Culvert," "Fish," "Arthur," and "Stauber." The present areas of these sections and the areas of other sections covering the river from the lake to the discharge section are given in Table No. 1, and are shown graphically on Plate I.

Isolated current measurements.—For the purpose of obtaining a general idea of the distribution of current velocities throughout the river, a few observations were taken at isolated points near the head of the river. For this purpose a meter was lowered from a boom extending out over the bow of the tug, and the tug was held in position

as nearly as possible by selecting natural ranges for the guidance of the master and engineman. The actual position of the tug was determined by transit intersections taken at 1-minute intervals. The meter was usually run five minutes at each of three or four different depths at each station. The results of these isolated measurements are shown on Plate I. Approximate surface velocities were obtained in taking soundings by allowing the tug to drift downstream and locating it by transit intersections at 1-minute intervals.

The discharge section.—The locality seeming to present the most favorable conditions for discharge measurements is the reach of the river, about 2 miles in length, beginning just below the mouth of Black River. This portion of the river is comparatively straight and uniform, and after a survey of the locality the discharge section, called section "Dry Dock," was selected at a point near the foot of the reach, where the river was a trifle wider and shallower than above or below. The general direction of the river at this place is northeast to southwest. The section is a little over 2,100 feet in width, and as observations for discharge were to be taken 100 feet apart, the section was divided into 21 partial areas, with a discharge station at the center of each (except in case of 2 end areas, the width of which varied with water stage). These stations were numbered 1 to 21, beginning on the American side at the northwest end. The section was fixed by a pair of cross ranges on either shore, and the stations were defined by diagonal ranges placed upstream on the American side. These were 2 by 2 inch poles set along the shore and bearing Roman numerals, the back range for all being a prominent telegraph pole at some distance from the river. Natural ranges were soon picked up for several stations near the Canadian shore, from which it was difficult to see the range poles in foggy weather.

The section was sounded December 24, 1898, with catamaran No. 1 and tug *Sand Beach*. Strips were tacked upon the meter reel of the catamaran to increase its circumference to 5 feet, measured along the phosphor-bronze wire, 0.065 inch in diameter, used as a lead line. This was so nearly accomplished that the greatest correction necessary to apply to depth-register readings was one-tenth of a foot.

The catamaran was made fast alongside the tug. A man was stationed on top of the house over the reel, where he had a good view of the shore ranges defining the section, and directed the engineman how to regulate the throttle. The master held his wheel so as to work across the stream very slowly and at a uniform speed. The sounding lead, in the form of a cast-iron "fish," was lowered through the opening in the floor of the catamaran prepared for the meter. The observer handled the reel and read the depth register. It was necessary to raise the lead but a foot or two between soundings, except when the bottom was changing rapidly, and by lowering the lead frequently, usually every ten or twenty seconds, the observer was able to feel the bottom and obtain a very accurate profile. A transitman, at a convenient triangulation station, located a sounding about every minute—at the drop of the flag—the flagman standing on the bow of the catamaran and being directed by the observer. The recorder noted the time of each sounding and designated the flag soundings, while a check was furnished by the transitman also recording time of pointings.

The section was sounded from northwest to southeast with 30-pound lead, taking 218 soundings in seventy-four minutes, and half of the section which had been passed over too rapidly the first time was resounded with 45-pound lead, taking 264 soundings in fifty-four minutes. Thus 482 soundings were taken in a little over two hours, an average of one sounding every sixteen seconds at a mean distance apart of 4.4 feet. The sounding wire was so nearly vertical that no correction was made for inclination; it probably did not amount to more than 0.2 foot, especially with 45-pound lead. The two lines agreed well; in a few cases the 45-pound lead indicated about 0.3 foot less depth than the 30-pound lead, but this difference was not systematic, and only once or twice was it exceeded. The form of the discharge section is shown on Plate I and in figure 1 of Plate XII. The area is given by the equation—

$a = 59{,}800$ square feet $+ 2{,}120$ (elevation water surface above 578.3 feet) between limits of 577 and 580 feet above mean tide at New York (by levels of 1877).

Water gauges.—A self-recording water gauge, U. S. L. S. No. 4, is located on the dock of Dunford and Alverson, 1,500 feet above the discharge section. This gauge, which is called "Dry Dock," was established in the spring of 1899 and is used as the section gauge.

Another self-recorder, L. S. No. 1, is located on the Grand Trunk Railway property near the head of the river, just below section "Arthur," the most restricted cross section. Gauge No. 5 was established here in the spring of 1899, but was burned on August 18, together with the record for the month. Gauge No. 1 was set up on August 21 at the same point. This gauge is called "G. T. R.," and the discharge of

the river is referred to the water stage at this point as the first step. The water level here is about 0.77 foot below the level as given by the staff gauge at Sand Beach.

In the fall of 1899 a self-recorder, L. S. No. 9, was established on the lake shore 600 feet above Fort Gratiot Light-House, and will be called the "Light-House" guage. The other gauges were established on existing docks, but as there were no permanent structures on the lake shore it was necessary to lay a submerged pipe feeding a well on shore. The gauge house is built on the bank over a well 3 feet in diameter and 16 feet deep. This well is a timber curb lined with brick. Two pipes of $1\frac{1}{2}$ inches diameter lead from the well to the lake. This work was done during the summer; as it necessitated work in an open trench in a location exposed to lake storms, the progress was slow. The gauge was started in October.

On July 1 Gauge No. 3 was placed at Roberts Landing at the head of the delta of St. Clair River and 26 miles below Fort Gratiot Light-House.

These four gauges with those at the head and foot of Detroit River, give an accurate knowledge of the governing slopes, and, taken in connection with the slope observations, occasionally taken with staff gauges placed at frequent intervals, they indicate the slopes in the several reaches in detail.

Detail slope observations.—In October, 1898, and in June, 1899, the distribution of fall in the channels connecting Lakes Huron and Erie was determined by reading a series of staff gauges located along the channels and connected by a line of precise levels. The gauges were graduated in feet and tenths, and the zero mark was set below the surface. A glass tube about one-half inch diameter and 18 inches long was fastened to the gauge against the ends of the graduation marks and extending above and below the water surface. In either end of the tube was a cork with a small hole to allow slow ingress and egress of the water at the bottom and of air at the top. The surface of the water in the tube was thus undisturbed by ripples, and readings could be taken to hundredths of a foot. All readers kept standard time and the gauges were read at ten-minute intervals from 7 a. m. to 5.30 p. m. for six days. The mean results are given in Table No. 2, and are platted on Plate II. To obtain true relative elevations of the gauges on St. Clair and Detroit rivers a correction of 0.378 foot must be added to the elevations given for the former. This difference was determined by the precise level line above mentioned, but since there may be a further correction necessary on the completion of the adjustment of a new line from tide water now in progress, and since the old records of Lake Huron levels contain the same error, the correction has not been applied in any of the results given in this report. When the new line from tide water is completed, it is the intention to readjust all of the water-level records. The discrepancy occurs between Windmill Point, at the head of the Detroit River, and New Baltimore, at north end of Lake St. Clair. The zero of the St. Clair Flats gauge has been estimated by a consideration of water levels.

TABLE No. 2.—*Slope in channels connecting Lakes Huron and Erie.*

Gauge.	Distance below Fort Gratiot Light-House.	Elevation water surface above mean tide at New York (levels of 1877).		Fall between gauges.						
				From—	To—	Distance	Feet.		Feet per mile.	
	Miles.	*Oct., 1898.*	*June, 1899.*			*Miles.*	*Oct., 1898.*	*June, 1899.*	*Oct., 1898.*	*June, 1899.*
Sand Beach			580.479							
Block I, No. 1	0.25	579.360	.030							
G. T. R.	.80		9.724	No. 1	G. T. R.	0.55		0.306		0.556
No. 2	.89	9.015		No. 1	No. 2	.64	0.345		0.539	
Waterworks	1.40		9.444							
Kendall's	2.20		9.170	G. T. R.	Kendall	1.40		.554		.396
No. 3	2.33	8.517				1.44	.498		.346	
Dry Dock	4.90		8.795	Kendall	Dry Dock.	2.70		.375		.139
No. 4	5.52	8.130		No. 3	No. 4	3.19	.387		.121	
Marysville, No. 5	8.30	7.741	8.304	Dry Dock.	No. 5	3.40		.491		.144
				No. 4	No. 5	2.78	.389		.140	
				No. 1	No. 5	8.05	1.619	1.726	.202	.216
St. Clair, No. 6	14.0	6.978	7.518	No. 5	No. 6	5.7	.763	.786	.134	.138
Marine City, No. 7	21.8	6.102	6.597	No. 6	No. 7	7.8	.876	.921	.112	.118
Algonac, No. 8	29.1	5.527	5.888	No. 7	No. 8	7.3	.575	.709	.080	.098
St. Clair Flats, No. 9	39.8	4.865	5.346	No. 8	No. 9	10.7	.662	.542	.062	.051
Windmill Point, No. 11	58.0	4.556	5.124	No. 9	No. 11	18.2				
12th st., Detroit, No. 12	66.2	3.888	4.526	No. 11	No. 12	8.2	.668	.598	.082	.073
Wyandotte, No. 14	75.7	3.366	3.974	No. 12	No. 14	9.5	.522	.552	.055	.058
Gibraltar, No. 15	83.2	1.990	2.650	No. 14	No. 15	7.5	1.376	1.324	.183	.177
				No. 1	No. 15	83.0	7.370	7.380	.089	.089
Amherstburg	82.5		2.517							

RATING OF METERS.

The only place available for rating meters was an old dry dock just above Black River, about 300 feet in length and 60 feet wide. The depth of water was about 7 feet, but bilge blocks on the bottom made it unsafe to run the meters at a greater depth than 3 feet. As the dock opens directly into the main river, there was a slight current in and out at times, and the passing of a boat close to the mouth of the dock would cause a very perceptible oscillation and stop operations for a short time.

A base line 200 feet long was laid out on one side of the dock, and cross ranges were set to mark the 50-foot marks as well as the ends of the base. The meter was lowered from a boom projecting about 7 feet over the bow of a small rowboat. At the shore end of the dry dock was mounted a 20-inch wood split pulley with two crank handles; at the river end a boom carrying at its end a small iron sheave projected about 8 feet over the edge of the dock. A $\frac{1}{4}$-inch diameter manila rope was passed around the pulley and sheave, one end being made fast to the bow of the small boat and the other to the stern. Two men at the pulley could propel the boat in either direction at a good rate of speed. For the highest velocities a tow rope was made fast to the upper strand of the rope passing around the pulley, and thus the man on the tow line would not draw the boat out of its course. The observer sat in the stern of the skiff, balancing the weight of the meter, and started and stopped the meter register on passing the ends of the base as defined by the ranges. The time of passing intermediate points was noted in the slower velocities, and in working up the notes served as an index of the regularity of speed.

While this method of rating included no arrangement for automatic make and break of the circuit at the base ends and did not do away with the disturbance caused by the boat, it was considered an improvement over the method of towing by a line on shore; the boat could not get out of its course and the rate of speed could be regulated much better, especially with slow velocities. A design for a rating apparatus in which the meter was suspended from a truck running on a single rail and providing for automatic make-and-break circuit was submitted early in the year, and it is believed its use would increase both the accuracy and rapidity of observations.

To eliminate the effect of the light current sometimes existing, the observations were made in pairs—forward and back—the two elements of a pair being taken at as nearly the same velocity as possible and one following the other closely in point of time. The observations were numbered consecutively, the odd numbers applying to runs toward the east and even numbers to those in which the meter moved toward the west. The results were platted on cross-section paper with revolutions per second and velocity in feet per second as abscissas and ordinates, respectively. An inspection of this plat usually indicated that a few observations contained greater discrepancies than could be attributed to errors of observation, caused by the passage of a boat or a mistake in reading, and such observations were rejected, care being taken to reject observations in pairs. Those observations which were made at a higher velocity than that in which the meter was to be used were generally omitted from the computations.

Reduction of rating observations.—In comparatively low velocities the relation of velocity to revolutions per second seemed to be expressed in general by an equation of the second degree, while above a certain velocity the points platted very nearly in a straight line. It was found that to apply a second-degree equation to all of the observations would result in a curve which would not conform closely to the platted points. The following method was therefore adopted: The place where the points appeared to depart from a straight line was first determined approximately by inspection. In applying the method of least squares all of the observations above this point were used in forming observation equations of the form $y=dx+e$, and the observations below this point were used in forming equations of the form $y=ax^2+bx+c$, while some of the observations on either side of the point of tangency were included in both sets. In these equations x represents revolutions per second and y the velocity in feet per second, a, b, c, etc., being unknowns. After the values a, b, and c for the curve and of d and e for the straight line had been determined by the solution of the normal equations, a trial was made analytically to see if the straight line were tangent to the curve. If not, then the location of the point at which the curve had the same direction as the straight line—that is, where the first differential coefficient of y in the two equations had the same value—served as a guide in a new arrangement of the observations about the supposed point of tangency in the same way as above. Two or three trials resulted in determining a curve and straight line which were tangent, and which fitted well the observed points.

While this method involved a re-formation and computation of the two sets of normal equations, it is believed to give a result which expresses the relation between

revolutions and velocity more accurately than to adjust one curve to a portion of the observations, and introduce a rigid condition of tangency in adjusting a straight line to the remaining observations.

The form of the computations for the rating of meter No. 1 B, made in October, is shown in Table No. 3, only a part of the observations being given.

TABLE No. 3.—*Meter rating No. 1 B.*

[Observations taken October 6, 1899.]

No. of observation.	Rating No.	Direction toward.	Number of revolutions.	Time of run.	Revolutions per second (x).	Velocity, feet per second (y).	x^2	x^3	x^4	xy	x^2y	Computed (y).	v	vv	Remarks.
69	1	E.	125	195.0	0.64	1.03	0.410	0.262	0.168	0.659	0.422	1.03	0.00	0.0000	Observations for curve equation.
70	2	W.	123	205.0	.60	.98	.360	.216	.130	.588	.353	.99	+ .01	.0001	
67	3	E.	129	175.4	.74	1.14	.548	.405	.300	.844	.625	1.14	.00	.0000	
68	4	W.	130	182.6	.71	1.10	.504	.358	.254	.781	.554	1.11	+ .01	.0001	
*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
41	27	E.	154	78.2	1.97	2.56	3.881	7.645	15.062	5.043	9.935	2.54	− .02	.0004	
42	28	W.	157	80.0	1.96	2.50	3.842	7.530	14.761	4.900	9.604	2.53	+ .03	.0009	
43	29	.....	155	81.4	1.90	2.46	3.610	6.859	13.032	4.674	8.881	2.45	− .01	.0001	
44	30	.....	156	77.8	2.01	2.57	4.040	8.121	16.322	5.166	10.383	2.59	+ .02	.0004	
39	31	.....	155	78.0	1.99	2.56	3.960	7.881	15.682	5.094	10.138	2.56	.00	.0000	Observations for straight-line equation.
40	32	.....	156	76.0	2.05	2.63	4.202	8.615	17.657	5.392	11.053	2.64	+ .01	.0001	
37	33	.....	155	70.6	2.20	2.83	4.840	10.648	23.426	6.226	13.697	2.83	.00	.0000	
38	34	.....	156	73.0	2.14	2.74	4.580	9.800	20.976	5.864	12.549	2.75	+ .01	.0001	
35	35	.....	156	63.8	2.45	3.13	6.002	14.706	36.024	7.668	18.788	3.14	+ .01	.0001	
36	36	....	156	73.0	2.14	2.74	4.580	9.800	20.976	5.864	12.549	2.75	+ .01	.0001	
33	37	.....	156	66.2	2.36	3.02	5.570	13.144	31.025	7.127	16.821	3.02	.00	.0000	
34	38	.....	156	61.2	2.55	3.27	6.502	16.581	42.276	8.338	21.264	3.26	− .01	.0001	
31	39	.....	157	64.6	2.43	3.10	5.905	14.349	34.869	7.533	18.306	3.11	+ .01	.0001	
32	40	.....	157	62.0	2.53	3.23	6.401	16.194	40.973	8.172	20.675	3.24	+ .01	.0001	
29	41	.....	156	63.2	2.47	3.16	6.101	15.069	37.222	7.805	19.279	3.16	.00	.0000	
30	42	.....	155	61.0	2.54	3.28	6.452	16.387	41.628	8.331	21.161	3.25	− .03	.0009	
27	43	.....	156	56.0	2.79	3.57	7.784	21.718	60.591	9.960	27.789	3.56	− .03	.0009	
28	44	.....	156	61.0	2.56	3.28	6.554	16.777	42.955	8.397	21.497	3.28	.00	.0000	
25	45	E.	156	58.8	2.65	3.40	7.022	18.610	49.308	9.010	23.875	3.39	− .01	.0001	
26	46	W.	157	52.2	3.01	3.83	9.060	27.271	82.084	11.528	34.700	3.84	.01	.0001	
*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
1	65	E.	158	43.2	3.66	4.63	13.396	....	....	16.946	....	4.65	+ .02	.0004	
2	66	W.	157	39.2	4.01	5.10	16.080	....	....	20.451	....	5.08	− .02	.0004	
3	67	E.	158	34.6	[illegible].57	5.78	20.885	....	....	26.415	....	5.78	.00	.0000	
4	68	W.	157	38.0	4.13	5.26	17.057	....	....	21.724	....	5.24	− .02	.0004	
													− .04	.0288	

Quantities for normal equations.

	x	y	x^2	x^3	x^4	xy	x^2y
For curve (observations 1–42).....	69.27	91.35	128.525	257.539	543.013	167.349	333.086
For straight line (observations 31–68)........	115.86	147.68	369.554	....	....	470.620	....

The normal equations for the curve are:

$$\text{I.}\quad 543.013a+257.539b+128.525c-333.086=o.$$
$$\text{II.}\quad 257.539a+128.525b+\ 69.27\ c-167.349=o.$$
$$\text{III.}\quad 128.525a+\ 69.27\ b+\ 42.0\quad c-\ 91.35\ =o.$$

The solution of which gives the following values for the unknowns:

$$a=.0684,\ b=.9503,\ c=.3983,\ \text{or}$$
$$y=.0684x^2+.9503x+.3983.$$

The normal equations for the straight line are:

$$\text{I.}\quad 369.554a+115.86b-470.620=o.$$
$$\text{II.}\quad 115.86\ a+\ 38.0\ b-147.68\ =o;$$

giving $a=1.2483$ and $b=.0803$, or $y=1.248x+.080$.

Finding the first differential coefficient of y with respect to x from both equations and placing them equal, we find the curve to have the same direction as the straight

line at $x=2.18$. The corresponding value for y is 2.794 by the curve and 2.801 by the straight line, a difference of .007 foot per second. At $x=1.9$ and $x=2.4$ the curve and straight line give the same values of y, that is, the straight line cuts the curve at these points, and between them the maximum difference between the values of y by the two equations is .007 foot per second. The difference is so small that a rearrangement is not necessary, and we may use the linear equation for the values of x above 2.40 and the second degree equation below this point.

The loci of the equations may now be platted on a large scale, and a rating table prepared in the usual manner. To determine the probable error of a single observation as a measure of the accuracy of the result, the computed values of y are filled in the proper column of the computation table and the residuals taken out as indicated. In this case we find $r=\sqrt{\frac{[vv]}{n-1}}=.014$. In Plate III the observations for this rating are platted to scale and the lines represented by the equations are drawn. Table No. 4 gives a summary of the rating equations of the meters used in determining vertical curves. Table No. 5 gives the rating equations of the meters used in measuring discharge, with the dates of the observations to which the several ratings were applied.

TABLE No. 4.—*Rating equations of the meters used in determining vertical curves.*

Meter No.	Date of rating.	No. of observations.	Equations.	Limiting values of x.	Probable error of a single observation.
6 A	Aug. 11, 21, 26, 1899	86	$y=.0271x^2+1.189x+.236$	00–3.70	.020
7 A	Aug. 17, 1899	86	$y=1.266x+.228$ $y=1.423x-.0073$	00–1.50 1.50–3.52	.022
8 B	July 18, 19, 25, 26, Aug. 1, 1899	140	$y=.0695x^2+1.0354x+.233$ $y=1.3030x-.0118$	00–1.50 1.50–4.00	.017
9 B	July 19, 25, 26, Aug. 1, 26, 1899	140	$y=1.097x+.259$ $y=1.276x+.072$	00–1.08 1.08–4.20	.023
10 B	July 21, Aug. 18, 26, 1899	134	$y=.076x^2+.991x+.296$ $y=1.289x+.007$	00–1.96 1.96–5.00	.018
11 B	July 22, 25, Aug. 4, 1899	168	$y=.089x^2+.942x+.304$ $y=1.27x+.007$	00–1.84 1.84–4.00	.018
12 B	July 22, 24, Aug. 4, 1899	120	$y=.0771x^2+.941x+.362$ $y=1.299x-.0489$	00–2.30 2.30–4.00	.016
13 B	July 28, 29, 1899	192	$y=.0701x^2+1.075x+.212$ $y=1.34x-.0323$	00–1.50 1.50–3.60	.014
14 B	July 28, 30, Aug. 18, 21, 25, 1899	152	$y=.043x^2+1.111x+.192$ $y=1.272x+.049$	00–1.40 1.40–5.80	.019
15 B	Aug. 1, 16, 1899	110	$y=.0316x^2+1.115x+.194$ $y=1.294x-.057$	00–2.80 2.80–4.20	.020
1 B	Oct. 2, 3, 1899	80	$y=1.237x+.138$	00–3.58	.026

TABLE No. 5.—*Rating equations of the meters used in discharge observations.*

Meter No.	Date of rating.	No. of observations.	Equations	Limiting values of x.	Probable error single observation.	Discharge measurements to which applied. Numbers.	Dates, 1899.
	1899.						
1 B	May 9, 10	121	$y=.075x^2+.905x+.399$ $y=1.2236+.0604$	00–2.14 2.14–5.80	.013	0–23	May and June.
1 B	Oct. 6	68	$y=.0684x^2+.9503x+.3983$ $y=1.248x+.080$	00–2.40 2.40–4.00	.014	24–70	July 1 to Oct. 23.
1 B	Mean of October and November rates					71–81	Oct. 27 to Nov. 21.
1 B	Nov. 22, 25	98	$y=.0675x^2+.897x+.4206$ $y=1.2172x+.0435$	00–2.37 2.37–5.00	.019	82–90	Nov. 23 to Dec. 10.
5 A	May 10, 11, 19	138	$y=.0238x^2+1.152x+.2537$ $y=1.296x+.030$	00–3.02 3.02–4.00	.024	6–23	To July 1.
5 A	July 30, Aug. 1, 9	102	$y=.0351x^2+1.1161x+.250$ $y=1.299x+.020$	00–2.10 2.10–2.40	.014	24–60	July, Aug., Sept.
5 A	Nov. 2	62	$y=.0161x^2+1.156x+.2224$	00–3.79	.021	61–90	Oct., Nov., Dec.

To give an idea of the variations in the rate of the same meter, Table No. 6 shows the velocity in feet per second corresponding to several values of x or revolutions per second. These values cover the range in velocity found at the discharge section.

It is seen that 1 B meter changed its rate between May and October, but later returned nearly to its original rate. It was at first thought that the change indicated by the October rating might have been a very temporary one, but a careful comparison of the results given by this meter with those obtained with the 5 A indicated that this change took place in June or July. It is seen that the May and July ratings of 5 A agree well, but a change occurs between July and November. The mean velocity at the discharge section was about 3.2 feet per second, and at this velocity the extreme difference in the equation for the same meter are about 3½ per cent for 1 B and 2¼ per cent for 5 A. These differences are sufficient to show the necessity of frequently rerating the meters in use.

TABLE No. 6.—*Comparison of rating equations of discharge meters.*

Meter.	Rating.	Velocity, feet per second. Revolutions per second. 0.5.	1.0.	1.5.	2.0.	2.5.	3.0.	3.5.
	1899.							
No. 1 B	May	0.87	1.38	1.92	2.51	3.12	3.73	4.34
No. 1 B	October	0.89	1.42	1.98	2.58	3.20	3.82	4.45
No. 1 B	November	0.88	1.38	1.92	2.48	3.09	3.70	4.30
No. 5 A	May	0.84	1.43	2.04	2.65	3.28	3.93	4.57
No. 5 A	August	0.82	1.40	2.00	2.62	3.27	3.92	4.57
No. 5 A	November	0.80	1.39	1.99	2.60	3.21	3.84	4.46

VERTICAL CURVES.

The fluctuations in current velocity have usually rendered the determination of the distribution of velocities in the vertical plane a difficult matter, for if the meter were left at one depth long enough to eliminate the effect of the short wave-like fluctuations or pulsations of the current a more permanent change might take place affecting the mean velocity at the station before all of the depths had been covered by the meter. This difficulty is overcome by the use of the multiple meter set, with which the whole vertical curve is determined at one observation.

Catamaran No. 2 was fitted up for this work with hand dynamo and necessary wiring. The method of use was as follows: The catamaran was firmly secured in position by head anchor and side kedges. At the lower end of the pair of parallel cables, between which the meters are suspended, a 200-pound mushroom sinker was attached. This occupied about 1.3 feet in height, so that the bottom meter was always at least 1.75 feet above the bottom of the sinker. The water stage being known, the corresponding depth for the station occupied was taken from a table. This depth divided by 10 gave the interval between meters. The depth of water at Stations 2 and 8, inclusive (numbering from northwest to southeast), is approximately 25 feet, while at Stations 9 to 19, inclusive, the depth is approximately 35 feet. At the shoaler stations the lowest meter was placed at the nine-tenths depth point. At the deepest stations the lowest meter was placed about 1.75 feet above the bottom of sinker, and the second meter occupied the nine-tenths depth point. Other meters were spaced uniformly at the tenth depth intervals, the cables being tagged at 5-foot intervals to assist in the measurements, and the location of each meter being checked by reading the depth register as the meter reached the water surface. For convenience of reference, we may call the bottom meter No. 10, the one originally at nine-tenths depth No. 9, and the surface meter No. 0. The center of the top meter was placed about six-tenths of a foot below the water surface, so that its blades were immersed.

The meters being in position with the mushroom sinker just free from the bottom, the initial readings of the registers were recorded, the hand dynamo was started, and the switch was closed, completing all the circuits through the meters and registers. At the instant of closing the switch with one hand a stop watch was started with the other, and at the opening of the switch at the end of the observation the watch was stopped in the same way. The actual time of run is evidently of minor importance, since any error in timing applies to all meters, and in working up the results no account was taken of the fractional seconds. Usually from one to ten observations

of one hundred seconds each and one observation of six hundred seconds were made with meters in first position as detailed above. This will be spoken of as a set of observations. The whole arrangement was then raised by the meter reel through one-tenth of the depth, and meter No. 1, which had been at one-tenth depth, was lowered on the cables six-tenths of a foot to immerse its blades. This resulted in bringing each meter (except No. 10, whose position at the outset was necessarily irregular) into the position just occupied by the one above it. This left the nine-tenths depth point without a meter and put No. 0 out of service. After repeating the observations in this position they were sometimes raised to a third position by a similar change, thus leaving the eight-tenths depth point without a meter and putting No. 1 out of service. Thus, either two or three sets of observations completed what was called a series. The advantage gained by this programme was to distribute small errors in meter rates, and to detect occasional large errors that will be considered later.

Under favorable conditions this programme could be carried out for three or four stations in one day, provided the spacing of meters did not have to be changed. There were several groups of stations so nearly of the same depth that the same meter spacing could be used for two or three stations. Three stations have been occupied in one day, including changing of meters. All stations were occupied three times—that is, on three separate days—and many of them four times. Table No. 7 gives a summary of the observations made for vertical curves, resulting in 245 mean curves, equivalent to over 1,500 observations of one hundred seconds each.

TABLE No. 7.—*List of observations for vertical curves, 1899.*

Station.	Dates stations were occupied.			Days occupied.	Total sets (meter positions).	Curves.	Observations.		
	August.	September.	November.				600 seconds.	300 seconds.	100 seconds.
1	....	18, 21	4	3	6	11	5	1	33
2	15	15	9	3	6	8	5	....	21
3	15, 16	15	7	4	9	14	5	....	31
4	16	15	7	3	6	8	5	....	20
5	16	21	7, 14	4	9	11	8	....	22
6	17	23	14	3	5	7	6	....	11
7	17	13	4, 14	4	8	13	8	....	38
8	15	21	9, 14	4	9	11	8	....	21
9	31	....	6, 10	3	8	9	7	....	26
10	29, 31	....	8	3	7	9	5	....	38
11	29	6, 12	8	4	9	14	6	1	47
12	29	6	8, 11	4	10	13	8	1	42
13	31	6, 12	11	4	9	13	4	3	49
14	30	5, 19	6	4	9	17	8	1	46
15	30	5, 19	6	4	9	14	6	1	42
16	30	5. 19	13	4	9	14	8	....	40
17	28	2	13	3	7	14	7	....	39
18	28	2	11, 13	4	9	14	9	....	26
19	22	16	10	3	6	10	5	....	37
20	14	16	9	3	6	9	5	....	22
21	....	16, 18	....	2	6	12	6	....	38
Total (28 days)	....	....	....	73	160	245	134	8	689

The record was made in a large notebook so that all results could be recorded on one double page. The page was headed with number of station, date, observer, etc. At the left of the page three columns gave the number of observation, time of starting, and length of run. Each meter was given a division of three columns, the first containing the initial and final register readings and the difference or number of revolutions for each observation; the second column was reserved for revolutions per second, and the third for velocity in feet per second. These last two columns were usually filled out in the office. In a column for remarks, at the right, the following data were given: The distance of each meter above the bottom of the sinker, the depth-register reading when bottom of sinker was at surface (usually adjusted to read zero), the register reading when the sinker touched bottom, and the reading when observation was taken. Data concerning wind and water stage were also entered here.

Reduction of observations for vertical curves.—After extending the revolutions per second and velocity in the proper columns of the field book, the actual depth at the station, according to the elevation of water surface shown by the self-registering gauge, was taken out for each set of observations; and this, combined with depth of

each meter below water surface, gave the actual proportional depth at which the meter was run. On account of rise or fall of water surface while observing, or because meters were spaced for one station and used for another of slightly different depth, these proportional depths were not always in even tenths, but very nearly so. The results were then tabulated on large sheets, and where several runs of one hundred seconds each were taken these were averaged together and given the same weight as one six hundred-second run. The group mean and the six hundred-second run were then platted on a large scale, using the actual proportional depth of a meter as ordinate, and mean velocity as abscissa. As these curves occupy too much space for reproduction, the method of treating them will be explained in some detail to show how far preconceived notions of regularity were allowed to influence their treatment. The consecutive points in one curve were first joined by straight lines, and in cases where the meter had not been run exactly at the even tenth the point where the straight line crossed the tenth depth line was taken as the true observation. Some reduction of this kind is necessary in order to render comparable the several observations taken at one station. Straight lines were used instead of curves to avoid any tendency to "smooth out" the results. The meters were so nearly at the proper depths, however, that one method would give practically the same result as another.

Usually two "A" meters were included in the multiple meter set. The large area presented to the current by the compass chamber and the comparatively massive gimbal required to support these meters seemed to render them untrustworthy when thus supported, and it was frequently the case that a sudden break in the curve occurred at the "A" meters. When such a break was found in the curve given by the meters in the first position, and the break *followed the meter* when all were raised to the second position, there seemed to be no doubt that the result of this meter, which was of different construction than the others, was in error, and its result was disregarded.

In some of the earlier observations the meter at the surface had been omitted in the observation in the first position. In such cases the line from the one-tenth depth to surface was drawn parallel to the corresponding line given by the observations in the second position. This had the effect of giving undue weight to the surface observation in second position. Again, it was of course impossible to obtain the bottom velocity, and if the meter was placed too close to the mushroom sinker, this had a retarding effect similar to that of the river bottom, as was shown by raising the sinker some distance above the bottom. When the meters were in second position, the nine-tenth depth point was also without a meter. It was therefore always necessary to extrapolate the curve to obtain the bottom velocity, and sometimes also for that at nine-tenths and eight-tenths depth. For this extension it did not seem practicable to establish any rigid rule and entirely eliminate the judgment of the computer. In this connection the following studies were made: In 1898 and 1899 fifty-nine vertical curves were measured with a single meter in the ordinary manner. With this method the meter may be placed closer to the bottom, and the lead weight being small has little effect in retarding the current. The single-meter observations for each station were plotted separately and a curve was sketched in to fit the points as nearly as possible. In the deeper stations the center of the meter was but five-hundredths of the depth above the bottom in the observation at greatest depth, so that the curve had to be extended but little beyond the observations. The velocities at mid depth and at the bottom were then taken from these curves and the ratio $\frac{v_{1\cdot0}}{v_{0\cdot5}}$ was obtained for each station ($v_{1\cdot0}$ being velocity at bottom and $v_{0\cdot5}$ that at mid depth). The value of this ratio varied from forty-two hundredths for station 2 to eighty-two hundredths for station 1, the mean value for all stations being sixty-two hundredths.

In connection with the discharge measurements of November 17, 23, and 24, and in addition to the regular discharge observations, a meter was run at nine-tenths depth and as near the bottom as possible. The velocities at nine-tenths depth and near the bottom were plotted to scale, and a straight line was drawn connecting each pair of points. The place where this straight line cut the line representing the river bottom was taken as the bottom velocity. The ratio of this to the velocity simultaneously observed at five-tenths depth gave $\frac{v_{1\cdot0}}{v_{0\cdot5}}=0.60$, 0.64, and 0.63 for November 17, 23, and 24, respectively. The mean value is thus found to be 0.62, the same as that given by the vertical curves taken with single meter. Further, the ratio $\frac{v_{1\cdot0}}{v_{0\cdot9}}$ was obtained in similar manner and gave 0.77, 0.70, and 0.77 for the three days, respectively, mean value 0.75. We now have the relations: Bottom velocity=0.62 of the velocity at mid depth and 0.75 of the velocity at nine-tenths depth. In extrapolating the curves

given by the multiple meter set these relations were used as guides only, not as rigid requirements to be filled in all cases.

The curves given by meters in first position always indicated the velocity at nine-tenths depth and sometimes that at a lower point, and the rate of decrease of velocity just above this point, together with the relations mentioned above, permitted the velocity at the bottom to be determined with some confidence. The other curves of that day were extended parallel to these, or nearly so, some weight being given to the relation of bottom to mid-depth velocity.

The velocities at the tenths of depth were then copied, the curve, or rather broken line, being used to determine those velocities not directly observed as explained above, and the latter were copied in ink of different color to make prominent the interpolated results. The curves of one set, usually two, were now averaged by taking the mean of the two or more observations at surface for a mean surface velocity, etc. This gave two or more set means according to the number of positions occupied by the meters on the day considered. The set means were obtained first in order to give equal weight to each position of the meters. The mean of these sets gave a day mean. The velocity at any given depth at one station did not usually show any marked persistent change during one visit; all of the observations made on one day could therefore be combined without fear of destroying individual characteristics further than to eliminate the wave-like fluctuations which are always present. The results for each station were thus reduced to three or four day mean curves, each of which represented the results obtained at the station during one visit.

The object sought in determining the law of the distribution of velocities in a vertical longitudinal plane, or, in other words, in determining the form of the "vertical curve," is to derive the coefficient by which the measured velocity of the particles passing any point in the plane must be multiplied to give the mean velocity of all the particles passing the vertical line through that point. It is frequently considered that the coefficient for a given point may be expressed as a function of the ratio of the depth of the point below the surface, to the total depth of the river. Whether this is in truth a function of the proportional depth of the point alone, or whether it is so involved with other conditions as to defy simple mathematical expression, is a question which has received some discussion; but in the case in hand, where the form at the vertical curve has been determined for each station, it is of comparatively little moment. It is generally admitted, however, that the coefficient mentioned above follows more closely the proportional depth than any other single variable.

Without making any assumptions concerning this law of variation, we may so treat the curves as to reduce them to the same scale, and if the coefficient does not bear a close relation to the proportional depth this will be shown by the dissimilarity of the curves. To this end, therefore, each curve was reduced to a "curve of coefficients," as follows: The mean velocity was determined for each curve by dividing by 10 the half sum of the surface and bottom velocities plus the sum of the velocities at the intermediate tenths of depth. This velocity was then divided in turn by the velocity at each tenth of depth, thus giving a coefficient by which the velocity at the point could be reduced to mean velocity. Since all depths are now expressed as tenths of the total depth at the station, and all velocities are expressed as a function of the mean velocity at the station, it is evident that not only may the curves at a single station be compared, but all curves are on the same scale and may be compared one with another.

Results of observations for vertical curves.—The resulting coefficients are shown in Table No. 8. This table contains all of the data necessary to reduce velocity observed at a station at any even tenth of depth to mean velocity at the station. Thus, if the velocity at three-tenths depth, station 4, be observed as 3 feet per second, the corresponding mean velocity at the station is $3.0 \times .929 = 2.79$ feet per second. Table No. 9 gives the values at the ratio $\frac{v}{v_m}$, where v is the observed velocity and v_m is the mean velocity. It is evident that the numbers in this table are the reciprocals of the corresponding numbers in the preceding table.

TABLE No. 8.—*Coefficients of tenths of depth* $c=\frac{v_m}{v}$.

Station.	Surface.	.1	.2	.3	.4	.5	.6	.7	.8	.9	Bottom.
1	0.990	0.940	0.900	0.876	0.887	0.928	0.979	1.048	1.138	1.270	1.490
2	.996	.943	.910	.901	.912	.930	.961	1.020	1.101	1.244	1.549
3	.893	.874	.877	.904	.938	.974	1.010	1.060	1.127	1.242	1.516
4	.915	.903	.909	.929	.943	.969	.992	1.033	1.089	1.183	1.479
5	.900	.884	.899	.910	.929	.958	.994	1.041	1.113	1.251	1.582
6	.938	.912	.904	.916	.930	.956	.984	1.025	1.092	1.227	1.532
7	.918	.895	.907	.913	.934	.961	.994	1.038	1.102	1.222	1.497
8	.901	.871	.882	.898	.918	.944	.983	1.055	1.163	1.306	1.628
9	.934	.896	.899	.914	.930	.953	.985	1.033	1.105	1.245	1.544
10	.946	.904	.917	.923	.940	.961	.990	1.026	1.082	1.192	1.479
11	.929	.898	.914	.929	.942	.958	.984	1.026	1.087	1.200	1.527
12	.930	.898	.909	.923	.938	.960	.989	1.032	1.092	1.196	1.533
13	.922	.901	.914	.929	.947	.963	.988	1.030	1.084	1.182	1.505
14	.922	.900	.913	.930	.949	.972	.999	1.037	1.084	1.166	1.448
15	.923	.894	.905	.925	.944	.965	.996	1.032	1.086	1.198	1.527
16	.910	.885	.908	.913	.933	.955	.990	1.043	1.111	1.230	1.596
17	.921	.895	.897	.913	.929	.953	.989	1.037	1.105	1.237	1.598
18	.906	.882	.896	.912	.926	.953	.982	1.034	1.117	1.271	1.636
19	.911	.882	.891	.912	.931	.955	.989	1.033	1.114	1.257	1.639
20	.919	.881	.887	.907	.929	.956	.991	1.037	1.109	1.265	1.649
21	.890	.875	.870	.882	.905	.940	.989	1.060	1.153	1.300	1.670
Mean	.924	.896	.900	.912	.930	.956	.988	1.037	1.107	1.232	1.554

TABLE No. 9.—*Ratios of tenths of depth* $r=\frac{v}{v_m}$.

Station.	Surface.	.1	.2	.3	.4	.5	.6	.7	.8	.9	Bottom.
1	1.010	1.064	1.111	1.142	1.127	1.078	1.021	0.954	0.879	0.787	0.671
2	1.004	1.060	1.099	1.110	1.096	1,075	1.041	.980	.908	.804	.646
3	1.120	1.144	1.140	1.106	1.066	1.027	.990	.943	.887	.805	.660
4	1.093	1.107	1.100	1.076	1.060	1.032	1.008	.968	.918	.845	.676
5	1.111	1.131	1.112	1.099	1.076	1.044	1.006	.961	.898	.799	.632
6	1.066	1.096	1.106	1.092	1.075	1.046	1.016	.976	.916	.815	.653
7	1.089	1.117	1.103	1.095	1.071	1.041	1.006	.963	.907	.818	.668
8	1.110	1.148	1.134	1.114	1.089	1.059	1.017	.948	.860	.766	.614
9	1.071	1.116	1.112	1.094	1.075	1.049	1.015	.968	.905	.803	.648
10	1.057	1.106	1.091	1.083	1.064	1.041	1.010	.975	.924	.839	.676
11	1.076	1.114	1.094	1.076	1.062	1.044	1.016	.975	.920	.833	.655
12	1.075	1.114	1.100	1.083	1.066	1.042	1.011	.969	.916	.836	.652
13	1.085	1.110	1.094	1.076	1.056	1.038	1.012	.971	.923	.846	.664
14	1.085	1.111	1.095	1.075	1.054	1.029	1.001	.964	.923	.858	.691
15	1.083	1.119	1.105	1.081	1.059	1.036	1.004	.969	.921	.835	.655
16	1.099	1.130	1.101	1.095	1.072	1.047	1.010	.959	.900	.813	.627
17	1.086	1.117	1.115	1.095	1.076	1.049	1.011	.964	.905	.808	.626
18	1.104	1.134	1.116	1.096	1.080	1.049	1.018	.967	.895	.787	.611
19	1.098	1.134	1.122	1.096	1.074	1.047	1.011	.968	.898	.796	.610
20	1.088	1.135	1.127	1.103	1.076	1.046	1.009	.964	.902	.791	.606
21	1.124	1.143	1.149	1.134	1.105	1.064	1.011	.943	.867	.769	.599
Mean	1.082	1.117	1.111	1.096	1.075	1.047	1.012	.964	.903	.812	.645

The curves of coefficients for all stations and the mean curve are shown graphically on Plate IV. In order to have the curves convex to the right, as is usual with velocity curves, the abscissas, representing coefficients, are made to increase toward the left. The ordinates represent depths. It is seen that there is a marked similarity in form among nearly all of the curves. The sharp retardation of the velocity at the surface is conspicuous, and it is thought that this must be due to the effect of the catamaran hulls. To see if this could be detected, surface velocities were observed for a few days while taking discharge, by running 1 meter at the surface between the catamaran hulls as usual, while another was lowered from a boom projecting over the bow. The effect, however, if due to the disturbing effect of the hulls, must extend some distance upstream, as no change was indicated by this method. It appears that the indicated velocity at one-tenth depth is greater, and that at the surface is less, than would be obtained without a disturbing influence; but since the discharge measurements were undertaken under the same conditions, no correction need be applied, and the results are given as observed. Another notable point is that the mean velocity is found just below the six-tenths depth point in nearly all the curves.

Station 1, 2, 3, 8, and 21 seem to have individual characteristics not shown by the others. An inspection of the form of the discharge section, fig. 1, Plate XII, will suggest the reason of this dissimilarity. The curves for the remaining 16 stations are so nearly alike that it is considered that the observations taken at them may be combined to bring out effects of wind and stage on the form of the curve.

Effect of wind.—Fifty-seven day-mean curves were observed at the 16 stations. These curves are divided into four groups, according to the direction of the wind, those observed when wind was northerly—that is, between northwest and northeast—being put in one group, easterly winds in another, etc. The results of this subdivision are given in the first four lines of Table No. 10.

TABLE NO. 10.—*Summary of vertical curves illustrating effect of wind and stage on form of curve.*

Number.	Number of daily mean curves.	Conditions.	Depth in tenths. 0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
		COEFFICIENTS.											
1	19	North wind..	0.9094	0.8926	0.9067	0.9213	0.9377	0.9599	0.9876	1.0319	1.0982	1.2226	1.5588
2	7	East wind ...	.9220	.8923	.9037	.9197	.9379	.9577	.9884	1.0357	1.1000	1.2174	1.5513
3	18	South wind..	.9324	.8963	.9026	.9156	.9319	.9567	.9901	1.0342	1.1013	1.2207	1.5482
4	13	West wind...	.9217	.8945	.9054	.9197	.9392	.9636	.9937	1.0346	1.0929	1.2122	1.5243
5	19 & 7	North and east winds.	.9127	.8925	.9059	.9209	.9377	.9594	.9878	1.0329	1.0987	1.2212	1.5568
6	18 & 13	South and west winds	.9279	.8955	.9038	.9173	.9350	.9596	.9916	1.0344	1.0978	1.2217	1.5382
7	30	578.7′ and above	.9170	.8939	.9081	.9217	.9398	.9604	.9892	1.0335	1.0966	1.2141	1.5276
8	27	Below 578.7′.	.9255	.8944	.9010	.9159	.9322	.9584	.9906	1.0340	1.1000	1.2245	1.5678
9	57	Mean..	.9210	.8942	.9048	.9189	.9362	.9595	.9899	1.0337	1.0982	1.2190	1.5466
		RATIOS.											
10	57	Mean........	1.0858	1.1183	1.1053	1.0882	1.0681	1.0422	1.0102	0.9674	0.9106	0.8203	0.6466
11		Computed *a* .	1.1133	1.1136	1.1070	1.0934	1.0724	1.0437	1.0065	.9600	.9026	.8320	.7447
12		Residuals.	+.0275	−.0047	+.0017	+.0052	+.0043	+.0015	−.0037	−.0074	−.0080	+.0117	+.0981

a Values given by the equation $x^2 = 1.239378 + .084648y - .769481y^2$ resulting from a least square adjustment of the 9 points 0.1 to 0.9 depth. y representing depth, and x ratio.

It is seen that the effect of wind is comparatively slight and does not extend to the two-tenths depth point. Since the general direction of flow through the section is from northeast to southwest the north and east winds are combined and the south and west winds are combined to bring out the effect of upstream and downstream winds; the results are shown in lines 5 and 6 of the table. These two curves are shown graphically on Plate V, and it is seen that the surface velocity is slightly retarded by the wind blowing against the current, but that the effect does not extend to the two-tenths depth. The comparative insignificance of wind effect on the form of the vertical curve may be partially due to the fact that the river curves gradually, both above and below the section, so that there is not a long straight reach for the wind to act upon. The effect of the catamaran hulls, already mentioned as a probable cause of the peculiar form of curve at the surface, may also mask, to some extent, the retarding or accelerating effect of the wind. However, it must be concluded that wind effect extends but a short distance below the surface at this section.

Effect of stage.—To test the effect of change in stage on form of vertical curve, the 57 curves were divided in two groups according as water stage at the section was below or above elevation 578.7. The results of this division are shown in lines 7 and 8 of Table No. 10, and are platted on Plate V. It appears that the surface velocity bears a somewhat greater ratio to the mean at high water than at low, but the effect is not shown below the two-tenths depth point. This difference may be partially accounted for by the fact that the northerly winds resulted in a comparatively high stage.

As observations for discharge were made at three, five, and seven tenths depths, no corrections were applied to the coefficients at these stations for stage and wind. The mean coefficients derived from the 57 curves are shown in line 9, and the mean ratios in line 10 of Table No. 10. Since these results are obtained at stations having no marked peculiarities of location and presenting no strong individual characteristicts, they should represent the relation of velocity to depth. But even if we omit the surface velocity, which is thought to be abnormal for reasons already given, and the bottom velocity, which was not directly observed, a least square adjustment does not appear to result in a close agreement of the points with any simple mathematical expression. It is found, however, that an ellipse of the form $x^2=1.239378+.084648 y-.769481 y^2$, where y is the proportional depth and x is the ratio, fits the nine points of the curve of ratios fairly well, though it does not agree with the ratio derived for the bottom within about 0.10. The computed values of x for this equation, and the residuals, are shown at the bottom of Table No. 10. The observed and computed curves of ratios are also platted on Plate V. While the agreement between these curves is not close enough to establish the law of change in velocity, it is of interest to notice that the computed curve, in the deduction of which the observed surface velocity was not included, gives the position of maximum velocity just below the surface. The position of the mean velocity as given by the observed curve is at 0.625 depth, and the nearly uniform location of this point shown by the station curves has been mentioned above.

FLUCTUATIONS IN WATER LEVEL.

The continual fluctuation in the height of water surface of the lakes is well known, and there are many questions in this phenomenon that deserve investigation. The only point, however, which will be touched upon here is the effect of the changes in stage on the determination of the discharge of the outlet. These variations in level are naturally greatest at the ends of the lake. Among the many examples of extreme fluctuations collected by the self-registering gauges, we have selected one to show the propagation of a wave from the lake through the outlet. The records of four gauges on December 7, 1899, are reproduced on Plate VI, all drawn to the same vertical and time scale. The locations of these gauges have already been indicated. From the gauge above the light-house, G. T. R. is less than a mile; Dry Dock is a little over 5 miles, and Roberts Landing is about 26 miles.

This particular wave was caused by both wind and barometer. In the morning a storm of some intensity was central over Duluth, and during the forenoon of the 7th the water level at the foot of Lake Huron had been abnormally depressed by a stiff south wind and the effect of the barometric gradient. The low passed the meridian of Port Huron about 3 p. m., causing a rearrangement of the isobars over Lake Michigan-Huron and a shift of wind from south to west. This removed the cause of the low water, and in the reaction the water rose to about as far above the normal as it had been below.

The rate of travel of the wave downstream is the point to which attention is called. It is seen that the maximum is reached at G. T. R. very soon after it occurred at light-house, but the maximum at Dry Dock occurs about fifteen minutes later, while nearly an hour is required for it to reach Roberts Landing. A study of this and several similar records led to the conclusion that the time required for a certain fluctuation in stage at G. T. R. to be felt at Dry Dock is fifteen minutes. This corresponds to a velocity of wave of 24 feet per second. The theoretical velocity, $V=\sqrt{g\,D}$, where D represents mean depth, would be about 31 feet per second. It is quite possible, however, that this time may be as much as three minutes in error, and if twelve minutes is the correct interval the velocity of translation is 30 feet per second, which corresponds closely with the theoretical velocity. The gradual loss of effect as the wave travels downstream, resulting in temporary increase in slope, is also clearly shown, as the rise at Roberts Landing is only about one-fifth as great as that at the lake. We may now turn to the effect of such changes in stage on the current velocity near the head of the outlet.

Fluctuations in current velocity.—The velocity of the stream filaments passing a fixed point in the cross section seems to be ever changing. These variations may be divided into at least two classes; the first class to include those fluctuations having a short period, but considerable amplitude, and the second class covering the more permanent changes which may be traced to changes in stage. During the discharge measurement of June 5, one catamaran was anchored on Station 20, and a meter was lowered to three-tenths depth. From 10 o'clock to 11 o'clock in the forenoon and from 1 o'clock to 4 o'clock in the afternoon, observations of one hundred seconds were made with this meter at five or six minute intervals. On Plate VII these results

are platted to scale, together with the records of the self-registering gauge at G. T. R. and at Dry Dock. The time ordinates for the former gauge are taken fifteen minutes early for the reason already explained.

It is seen that there is a marked similarity between these curves of stage and discharge. The fluctuation in stage, with an amplitude of over 1 foot, is shown in the discharge curve by an extreme variation in velocity of nearly a foot per second. This represents, then, the second class of fluctuations in current velocity where the cause is traced directly to variations in stage.

The first class of fluctuations does not admit of such simple treatment. Although quite a number of continuous current observations at a single station were made, taking frequent register readings to show the variations in fifteen second intervals, they can not be said to have contributed much to the investigation of the cause of these momentary fluctuations. The most valuable observations were those made on September 23, when the two catamarans were held 150 feet apart, and two small boats were placed between them 50 feet apart, each boat and catamaran having a meter running at the same depth and taking simultaneous readings at fifteen second intervals. Some of the results of this work are shown on Plates VIII, IX, and X. In the first three sets, Plate VIII, the meters were in a line across the stream and 50 feet apart, while in the remaining sets, Plates IX and X, the line of meters extended in the direction of the current. In the first sets it is seen that two adjacent meters may follow each other for a time, but will soon depart, when another pair will act together. This serves to bring out the fact that these minor fluctuations do not affect the entire cross section alike, and in fact that they are not synchronous over any large portion of it. Neither can the fluctuations be traced with accuracy through the four positions, as would be the case if a wave of great extent passed across the stream diagonally.

In the remaining curves taken with the meters in line of current the similarity of the four curves seems to be plain. Although a certain wave, if we may so speak of it, in the curve of the upstream meter may die out or change its form before reaching the last meter in the line, there are so many crests and troughs that may be followed through the series that little doubt can remain that these fluctuations travel downstream for some distance without much diminution in energy. The time required to travel 150 feet appears to be about one minute, giving a velocity of only about 2½ feet per second. As this is less than one-tenth of the velocity of the fluctuations of the second class, it points to the conclusion that the two classes are quite distinct, both in immediate cause and in character.

The theoretical result of this brief study of fluctuations is rather meager. The changes in the height of water surface travel downstream as waves, with a velocity of some 30 feet per second. The resulting variations in water surface gradually diminish in amplitude as the wave passes downstream, but is still apparent at the head of the delta. These variations in stage cause changes in velocity which are felt over the entire width of the river. The rate of travel of these resulting changes in velocity appears to be the same as that of the change in water surface, and it is probable that the variations in velocity from this cause also diminish as the effect is extended downstream.

Minor fluctuations or pulsations in current velocity of a much shorter period, but of considerable amplitude, are especially marked at times of violent fluctuations in water surface, but they can not be traced directly to this cause. The extent of these pulsations in a line across stream is very limited, but they may be traced in a longitudinal direction for some distance, and the velocity of propagation is low. While the extent of these disturbances in a vertical direction is not well established, it is known that the whole depth of the river is subject to them, though it appears that in general the whole depth is not affected at the same time, or at least that the point of maximum effect is not at a fixed depth below the surface. All of these effects are such as might be caused by the action of the irregularities of the bottom of the river on a current which has been rendered nonuniform by changes in stage.

The practical results derived are, first, that so far as the more permanent fluctuations are concerned, since they follow the gauge, little will be gained by reading a meter at one station continuously while taking a discharge with another meter, with the idea of correcting observations made with the discharge meter according to the fluctuations observed with the stationary meter; because the discharge observations may as well be referred to gauge at once; and, second, since the pulsations of short period are not synchronous over the entire section, it will not be possible to use the results obtained with the stationary meter to eliminate the effect of these pulsations on the results given by the discharge meter. This led to a discontinuance of the plan adopted early in the season of keeping one meter at a fixed point while measuring the discharge with another meter, though in a section where prominent natural or artificial obstructions exist in the channel this method may be of service.

OBSERVATIONS FOR DISCHARGE.

The characteristics of the discharge section, the method of defining it by cross ranges on either shore, and the fixing of the stations 100 feet apart by diagonal ranges upstream have already been described.

The party consisted of the observer and recorder and 3 men to shift anchors, handle the catamaran, and lower the meters, beside the master and engineman on the tug. In taking a discharge measurement the catamaran occupied Stations 1 to 21 consecutively, usually starting at Station 1 at the northwest end of the section. The catamaran swung from a headline about 1,000 feet in length leading to a 300-pound fluke anchor. The first position of the anchor was directly upstream from Station 5, the catamaran being made fast to some piles just northwest of Station 1 while the headline was run out. After observing at Station 1, the side line was payed out and the headline hauled in by the winch forward, bringing the catamaran to Station 2. Continuing in this way to Station 4, the side line was then transferred from the piles to a small kedge cast off the port side and Stations 5, 6, and 7 occupied in succession, the current shearing the catamaran into position with the aid of the rudders. The tug then shifted the head anchor about 700 feet to the southeast and brought the side kedge to Station 7. Stations 8 to 12 could then be taken, when another shift of anchors was required. By thus keeping the head anchor in advance of the catamaran in the direction of movement the current did the work of shifting from station to station, and it was only necessary to pay out the side line and with the winch so adjust the headline as to bring the catamaran on the section.

A few observations early in the season were made with but one meter, No. 1B, run at a single depth at each station. When a second meter was received the two were used simultaneously at different depths. All discharges were measured with meters 1B and 5A. From May 6 to August 23 meter 1B was run at three-tenths depth and meter 5A at five-tenths depth, one observation of one hundred seconds being taken with the two meters simultaneously, except in the case of 6 measurements in June when the 1B meter was in use elsewhere. From August 24 to September 22 meter 1B was run at three-tenths depth while meter 5A occupied successively the 0.5 and 0.7 depth points. From October 11 to the end of the season meter 1B was run at the five-tenths depth point, while 5A occupied successively the 0.3 and 0.7 depth. Thus up to August 24 the discharge at one station was measured in general by two meters running simultaneously for one hundred seconds, one at three-tenths depth and the other at five-tenths, and after that date two observations of one hundred seconds each were made at each station with two meters, the velocities at three, five, and seven tenths depths being measured. Since with the method used the time consumed in moving from station to station regulated to a great extent the time required to complete a discharge measurement, it is thought that the length of run at each station might be further increased to advantage.

When in position at a station, the water stage being known, a table gave the depth of water at the station and the meters could be set at once to the proper depth. The A-meter cable was wound on the reel and the depth was determined by the depth register, which was set to read zero when center of meter was at water surface. The cable of the B meter was graduated in feet by cord lashing and this meter was raised and lowered by hand. The meters being at the proper depth, the two registers were started together, one with either hand. After about thirty seconds the circuit in the direction part of the A meter was made and the observation for direction of current taken at the same time as the velocity observation. At the end of one hundred seconds the registers were stopped in the same way they had been started, both meters being timed by one stop watch.

The notes were taken in books specially prepared for the purpose, a separate book being used for each meter, and gave the following general information: Date, number of meter, recorder, observer, direction of wind, and gauge reading at beginning of measurement. For each observation the following data were given in their respective columns: Station number, time of day, depth of meter in feet, and proportional depth, initial and final register readings and difference, time of run, revolutions per second, and velocity in feet per second, all on left-hand page. On the right-hand page were given the observation for direction of current, intermediate readings of meter registers at intervals of twenty or twenty-five seconds, and any remarks pertaining to the work. This page was also utilized later in taking from the records of self-registering gauges the water level at the head of the river and at the section for each single observation. The revolutions per second and sometimes the velocities were carried out in the field; further reduction was necessarily left for the office. When conditions were favorable a complete measurement could be made in four hours; but the number of vessels passing was so great that delays were frequent and the time occupied in a measurement was usually five hours and sometimes greater.

REDUCTION OF OBSERVATIONS FOR DISCHARGE.

Water levels and partial areas.—The division of the section into 21 partial areas and the method of determining the profile of the bottom have been described above. The partial areas were determined for a datum stage of 578.3 feet above mean tide at New York, and each area was corrected to actual water area according to the elevation of water surface at the time of making the discharge observation. The elevations of water surface were scaled from the record of self-registering gauge dry dock located a short distance above the section, to which all section areas are referred. The elevations by gauge G. T. R. near the head of the river were taken off in the same way, except that fifteen minutes were allowed for a given change in stage at G. T. R. to be felt at the section, as already explained. Thus the readings used for this upper gauge were those that occurred fifteen minutes before the time of making the discharge observation. The gauge readings were first taken off in the field books and afterwards transferred to the computation books in proper order. The arithmetical mean of the 21 or 42 readings was used as the mean elevation of water surface for a given measurement.

In a few cases where the water surface at the time of taking the high velocity stations was quite different from that obtaining when the observation at the low velocity stations were made, a weighted mean was used, where each gauge reading was given a weight corresponding to the amount of water passing the partial area measured at the time the given gauge reading was shown. This was seldom necessary, however, because, although the water stage was by no means constant, its cycle was such that a weighted mean would not differ from the arithmetical mean by as much as 0.01 foot.

Observed velocities.—Revolutions per second were reduced to observed velocities by the rating tables prepared for each meter as explained under the head of meter rating. The dates for which the several rating equations were used has also been indicated in Table No. 5. The observed velocities were first carried out in the field book and all work in field books was checked before being used in the computations. The intermediate readings taken at intervals of twenty or twenty-five seconds were not used in the computations except to check errors in initial and final readings and to indicate whether the current was fluctuating badly in cases where a considerable discrepancy was shown between the mean velocity deduced from two simultaneous meter readings.

Coefficients of reduction.—Reference has been made to the use of the vertical curves in reducing the velocity at a given point to the mean velocity of all particles passing a vertical line through the point, and attention has been called to the similarity of the curves at the several stations. After a careful examination of the mean station curves it was concluded that the curves for the seven stations, 4, and 10 to 15, inclusive, were so nearly alike that the differences were as likely to be due to erroneous observation as to actual differences in station characteristics; the mean of the seven curves was therefore used for all of these stations. The mean value for these seven stations (Table No. 8) of the coefficient at the three-tenths depth point was 0.927, the highest 0.930, and the lowest 0.923. The mean at five-tenths depth was 0.964, highest 0.972, lowest 0.958; mean at the seven-tenths depth 1.031, highest 1.037, lowest 1.026. In like manner the seven curves for Stations 5, 6, 7, 9, 16, 17, and 19 were combined, giving the following results: Three-tenths depth mean 0.913, highest 0.916, lowest 0.910; five-tenths depth mean 0.956, highest 0.961, lowest 0.953; seven-tenths depth mean 1.036, highest 1.043, lowest 1.025. For the remaining seven stations, Nos. 1, 2, and 3 in shallow water, No. 8 at top of steep bank, No. 18 the deepest station, and Nos. 20 and 21 at southeast end of section, individual curves were used.

A raft of logs anchored above the section extended over Stations 1 and 2 during a part of the season, and the coefficients used were varied according to the conditions existing, the curve in which the surface velocity was comparatively low being used when the logs obstructed the section. The discharge passing areas one and two is about 3 per cent of the total discharge, so that a small error in coefficients here can have but a trifling effect on the result obtained for the whole section.

TABLE No. 11.

[Measurement No. 59. Date, September 14, 1899. Wind, southeast, 3-8 miles in a. m.; northeast, 8 miles in p. m. Resultant wind constant, +32.]

Station No.	Time of day.	Elevation of water surface above M. T. N. Y. (in feet).			Area of section (square feet).		Observed velocities at depth in feet per second.				Coefficients used to obtain mean velocity.			Mean velocities and discharge deduced from—							
														Meter 1B at 0.3 depth.		Meter 1B at 0.3 depth.		Meter 5A at 0.5 depth.		Meter 5A at 0.7 depth.	
		At G. T. R.	At dry dock.	Difference.	Correction for gauge.	Water area.	1B 0.3.	1B 0.3.	5A 0.5.	5A 0.7.	0.3 depth.	0.5 depth.	0.7 depth.	Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.
a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v
1	8.31	579.78	578.83	0.95	+60	1,223	1.22		1.14		0.923	0.892	0.959	1.13	1,382			1.02	1,247		
	.34	.78	.83	.95	60			1.22		1.07						1.13	1,382			1.03	1,260
2	8.50	.71	.82	.89	52	2,160	1.59		1.57		.902	.968	1.058	1.43	3,089			1.52	3,283		
	.52	.71	.82	.89	52			1.56		1.54						1.41	3,046			1.63	3,521
3	9.03½	.69	.82	.87	52	2,442	2.45		2.30		.904	.974	1.060	2.21	5,396			2.24	5,471		
	.06	.70	.82	.88	52			2.80		2.26						2.53	6,178			2.40	5,860
4	9.55	.70	.80	.90	50	2,552	3.15		2.97		.927	.964	1.031	2.92	7,452			2.86	7,299		
	.57	.71	.80	.91	50			2.97		2.62						2.75	7,018			2.70	6,890
5	10.03½	.67	.80	.87	50	2,529	3.46		3.29		.913	.956	1.036	3.16	7,992			3.15	7,967		
	.06	.67	.80	.87	50			3.19		2.96						2.91	7,359			3.07	7,764
6	10.18	.66	.78	.88	48	2,558	3.23		3.03		.913	.956	1.036	2.95	7,546			2.90	7,418		
	.20	.66	.78	.88	48			3.36		2.91						3.07	7,853			3.01	7,700
7	10.27½	.64	.78	.86	48	2,534	3.49		3.29		.913	.956	1.036	3.19	8,084			3.15	7,983		
	.30	.65	.78	.87	48			3.66		3.17						3.34	8,463			3.28	8,311
8	10.37	.65	.78	.87	48	2,558	3.56		3.39		.890	.939	1.052	3.17	8,109			3.18	8,135		
	.39	.65	.78	.87	48			3.91		3.65						3.48	8,902			3.84	9,823
9	10.53	.65	.78	.87	48	3,278	3.70		3.64		.913	.956	1.036	3.38	11,079			3.48	11,407		
	.56	.65	.78	.87	48			4.01		3.23						3.66	11,998			3.35	10,981
10	11.21	.77	.84	.93	54	3,538	3.96		3.69		.927	.964	1.031	3.67	12,985			3.56	12,595		
	.23	.76	.84	.92	54			3.90		3.62						3.62	12,808			3.73	13,197
11	11.29	.72	.84	.88	54	3,525	4.06		3.87		.927	.964	1.031	3.76	13,254			3.73	13,149		
	.31	.72	.84	.88	54			4.02		3.69						3.73	13,149			3.80	13,395
12	11.38	.72	.83	.89	53	3,496	4.31		4.18		.927	.964	1.031	4.00	13,984			4.03	14,089		
	.40	.72	.83	.89	53			4.27		3.78						3.96	13,844			3.90	13,634
13	11.49½	.68	.82	.86	52	3,470	4.24		3.83		.927	.964	1.031	3.93	13,637			3.69	12,804		
	.51½	.68	.82	.86	52			4.30		3.77						3.99	13,845			3.89	13,498
14	12.04½	.68	.82	.86	52	3,400	4.14		4.05		.927	.964	1.031	3.84	13,056			3.90	13,260		
	.06½	.68	.82	.86	52			4.27		4.05						3.96	13,464			4.18	14,212
15	1.17	.71	.82	.89	52	3,362	4.42		4.20		.927	.964	1.031	4.10	13,784			4.05	13,616		
	.20	.71	.82	.89	52			4.42		3.87						4.10	13,784			3.99	13,414
16	1.44	.73	.84	.89	54	3,421	4.26		4.08		.913	.956	1.036	3.89	13,308			3.90	13,342		
	.47	73	.84	.89	54			4.34		3.95						3.96	13,547			4.09	13,992
17	1.56	.76	.84	.92	54	3,515	4.35		4.11		.913	.956	1.036	3.97	13,955			3.93	13,814		
	.58	.73	.84	.89	54			3.95		3.44						3.61	12,689			3.56	12,514

TABLE No. 11—Continued.

Station No.	Time of day.	Elevation of water surface above M. T. N. Y. (in feet.)			Area of section (square feet).		Observed velocities at depth in feet per second.				Coefficients used to obtain mean velocity.			Mean velocities and discharge deduced from—							
														Meter 1B at 0.3 depth.		Meter 1B at 0.3 depth.		Meter 5A at 0.5 depth.		Meter 5A at 0.7 depth.	
		At G. T. R.	At dry dock.	Difference.	Correction for gauge.	Water area.	1B 0.3.	1B 0.3.	5A 0.5.	5A 0.7.	0.3 depth.	0.5 depth.	0.7 depth.	Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.	Velocity.	Discharge.
a	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*j*	*k*	*l*	*m*	*n*	*o*	*p*	*q*	*r*	*s*	*t*	*u*	*v*
18	2.07	0.73	0.84	0.89	54	3,558	3.97	....	3.82	....	0.918	0.956	1.032	3.64	12,951	......	....	3.65	12,987	......	....
	.08	.73	.84	.89	54	....	....	4.10	....	3.53	....	....	....	......	....	3.76	13,378	......	....	3.64	12,951
19	2.20	.72	.84	.88	54	3,284	3.80	....	3.60	....	.913	.956	1.036	3.47	11,396	......	....	3.44	11,297	......	....
	.22	.72	.84	.88	54	....	....	3.89	....	3.34	....	....	....	......	....	3.55	11,659	......	....	3.46	11,363
20	2.43$\frac{1}{2}$	.75	.84	.91	54	2,905	3.55	....	3.40	....	.909	.954	1.048	3.23	9,383	......	....	3.24	9,412	......	....
	.45$\frac{1}{2}$	.75	.84	.91	54	....	....	3.70	....	3.34	....	....	....	......	....	3.36	9,761	......	....	3.50	10,167
21	2.54$\frac{1}{2}$	.74	.84	.90	56	1,627	2.19	....	2.16	....	.890	.931	1.037	1.92	3,124	......	....	2.05	3,336	......	....
	.56$\frac{1}{2}$	579.74	578.84	.90	+56	....	....	2.18	....	1.82	....	....	....	......	....	1.91	3,107	......	....	1.97	3,205
Sum	....	....	....	......	+1,099	60,935	....	....	....	....	....	....	....	......	204,946	......	207,234	......	203,911	......	207,652
Mean	....	579.707	578.819	.888	....	....	....	....	....	....	....	....	....	......	....	......	....	......	....	......	....

Determination of discharge.—Table No. 11 exhibits the method of reduction of one complete measurement of the discharge. Columns *a*, *b*, *c*, *d*, *h*, *i*, *j*, *k* are taken from the field books, the water levels having been transferred to the latter from gauge-record sheets. The datum areas are not given in the tables, but are kept on a separate sheet transferred from page to page of the computation book as required. Neither are the coefficients repeated on each page of the computation book, though they have been inserted here for the sake of completeness. Column *f* is obtained directly from *d*, correction = width of partial area times gauge height above datum. These corrections applied to datum areas give water areas. Columns *o*, *q*, *s*, *u* are derived from the corresponding observed velocities by the application of the proper coefficient. The partial discharges in columns *p*, *r*, *t*, and *v* are obtained by multiplying each partial water area into the deduced mean velocity. At the bottom of the table are given the mean gauge readings and fall, the total area of section, and the total discharge given by the four sets of observations. The mean of these four discharges is used as the observed discharge. The results of the ninety measurements of discharge made in 1899 are shown in Table No. 12, and will now be taken up to determine the relation of discharge to lake stage.

TABLE NO. 12.—*Investigation of lake levels.*

SUMMARY OF MEASUREMENTS OF DISCHARGE OF ST. CLAIR RIVER, MADE IN 1899.

No. of measurement.	Date of observation.	Wind constant.	Water levels above mean tide at New York (levels '77). G. T. R.	Dry dock.	Fall.	Meters used.	Depth ratio.	Discharge, in hundred cubic feet per second. Observed.	Corrected for wind.	Computed.	Residual.
1	Apr. 29	—123	578.850	578.030	.820	1 B	0.5	1,880	1,909	1,848	(*a*)
2	May 1	—345	578.750	578.000	.750	1 B	.5	1,836	1,916	1,778	(*a*)
3	3	+117	579.120	578.170	.950	1 B	.5	1,912	1,885	1,956	(*a*)
4	4	0	578.956	578.071	.885	1 B	.5	1,897	1,897	1,898	(*a*)
5	5	+ 26	579.021	578.153	.868	1 B	.5	1,909	1,903	1,916	(*a*)
6	6	— 4	579.041	578.198	.843	1 B, 5 A	0.3, .5	1,942	1,943	1,912	—30
7	23	+ 88	579.326	578.455	.871	1 B, 5 A	.3, .5	2,016	1,995	1,989	—27
8	25	—191	579.180	578.340	.840	1 B, 5 A	.3, .5	1,940	1,985	1,896	(*c*)
9	29	—195	579.237	578.422	.815	1 B, 5 A	.3, .5	1,944	1,990	1,906	—38
10	31	—279	579.140	578.330	.810	1 B, 5 A	.3, .5	1,865	1,930	1,867	+ 2
11	June 2	+158	579.435	578.558	.877	1 B, 5 A	.3, .5	2,042	2,006	2,026	—16
12	3	— 2	579.307	578.438	.870	1 B, 5 A	.3, .5	1,990	1,991	1,964	—26
13	5	—183	579.392	578.537	.855	5 A	.3	1,960	2,003	1,938	(*a*)
14	6	+ 12	579.431	578.561	.870	5 A	.3	2,033	2,031	1,990	(*a*)
15	7	—230	579.379	578.519	.860	5 A	3	1,964	2,017	1,925	(*a*)
16	8	+ 69	579.567	578.668	.899	5 A	3	2,067	2,051	2,030	(*a*)
17	10	+ 58	579.558	578.651	.907	5 A	.3	2,059	2,046	2,026	(*a*)
18	12	—409	579.391	578.597	.794	5 A	.3	1,944	2,037	1,887	(*a*)
19	13	—333	579.376	578.519	.858	1 B, 5 A	.3, .5	1,933	2,011	1,901	—32
20	14	—162	579.501	578.626	.875	1 B, 5 A	.3, .5	1,942	1,980	1,963	+21
21	15	+139	579.639	578.776	.863	1 B, 5 A	.3, .5	2,023	1,991	2,060	+37
22	16	+ 78	579.810	578.933	.878	1 B, 5 A	.3, .5	2,108	2,090	2,078	—30
23	17	+ 56	579.655	578.742	.913	1 B, 5 A	.3, .5	2,051	2,038	2,044	— 7
24	July 10	— 85	579.850	578.964	.886	1 B, 5 A	.3, .5	2,071	2 091	2,048	—23
25	11	+ 9	579.876	578.960	.916	1 B, 5 A	.3, .5	2,106	2,104	2,076	—30
26	12	+ 61	579.852	578.989	.864	1 B, 5 A	.3, .5	2,118	2,104	2,082	—36
27	15	— 74	579.789	578.933	.856	1 B, 5 A	.3, .5	2,053	2,070	2,039	—14
28	17	+227	580.054	579.154	.900	1 B, 5 A	.3, .5	2,189	2,131	2,164	—25
29	18	0	579.890	579.026	.864	1 B, 5 A	.3, .5	2,068	2,068	2,075	+ 7
30	19	+ 91	579.951	579.065	.887	1 B, 5 A	.3, .5	2,072	2,051	2,108	+36

TABLE No. 12.—*Investigation of lake levels*—Continued.

SUMMARY OF MEASUREMENTS OF DISCHARGE OF ST. CLAIR RIVER, MADE IN 1899—Continued.

No. of measurement.	Date of observation.		Wind constant.	Water levels above mean tide at New York (levels '77).			Meters used.	Depth ratio.	Discharge in hundred cubic feet per second.				Water level light-house.
				G. T. R.	Dry dock.	Fall.			Observed.	Observed, corrected for wind.	Computed.	Residual.	
31	July	20	−150	579.815	578.975	0.840	1 B, 5 A	0.3, .5	2,039	2,074	2,027	−12	....
32		22	+135	579.915	579.044	.870	1 B, 5 A	.3, .5	2,109	2,077	2,113	+ 4	....
33		24	+ 58	579.847	578.995	.852	1 B, 5 A	.3, .5	2,060	2,046	2,081	+21	....
34		25	+ 46	579.850	578.990	.860	1 B, 5 A	.3, .5	2,068	2,057	2,078	+10	....
35		26	−236	579.786	578.937	.849	1 B, 5 A	.3, .5	1,967	2,022	2,001	+34	....
36		27	+ 66	579.988	579.100	.888	5 A	.5	2,093	2,078	2,110	+17	....
37		28	− 6	579.883	579.015	.868	1 B, 5 A	.3, .5	2,053	2,054	2,072	+19	....
38		29	− 17	579.883	579.028	.856	1 B, 5 A	.3, .5	2,082	2,086	2,069	−13	....
39	Aug.	3	− 37	[9.91]	579.020	[.89]	1 B, 5 A	.3, .5	2,063	2,072	2,070	(*d*) + 7	....
40		5	+ 26	[9.94]	579.040	[.90]	1 B, 5 A	.3, .5	2,060	2,054	2,091	(*d*) +31	....
41		7	+ 80	[9.95]	579.062	[.89]	1 B, 5 A	.3, .5	2,099	2,080	2,105	(*d*) + 6	....
42		8	+ 61	[9.89]	579.010	[.88]	1 B, 5 A	.3, .5	2,083	2,069	2,090	(*d*) + 7	....
43		12	0	[9.84]	578.955	[.88]	1 B, 5 A	.3, .5	2,031	......	......	(*c* and *d*)	....
44		14	+172	[9.84]	578.974	[.87]	1 B, 5 A	.3, .5	2,105	2,065	2,106	(*d*) + 1	....
45		15	+185	[9.85]	578.960	[.89]	1 B, 5 A	.3, .5	2,109	2,066	2,111	(*d*) + 2	....
46		16	+ 56	[9.81]	578.929	[.88]	1 B, 5 A	.3, .5	2,054	2,041	2,073	(*d*) +19	....
47		22	+184	580.021	579.151	.870	1 B, 5 A	.3, .5	2,170	2,127	2,143	−27	....
48		23	+103	579.792	578.915	.877	1 B, 5 A	.3, .5	2,067	2,043	2,080	+13	....
49		24	− 87	579.677	578.828	.848	1 B, 5 A	0.3, .5, .7	2,003	2,023	2,015	+12	....
50		28	+101	579.709	578.873	.836	1 B, 5 A	.3, .5, .7	2,069	2,045	2,064	− 5	....
51		29	+ 43	579.698	578.860	.838	1 B, 5 A	.3, .5, .7	2,041	2,031	2,049	+ 8	....
52		30	−116	579.560	578.694	.866	1 B, 5 A	.3, .5, .7	1,999	2,026	1,986	−13	....
53		31	− 56	579.618	578.767	.851	1 B, 5 A	.3, .5, .7	2,007	2,020	2,011	+ 4	....
54	Sept.	1	+ 43	579.564	578.740	.823	1 B, 5 A	.3, .5, .7	2,019	2,009	2,022	+ 3	....
55		6	+ 74	579.680	478.854	.825	1 B, 5 A	.3, .5, .7	2,028	2,011	2,052	+24	....
56		7	− 96	579.402	578.578	.824	1 B, 5 A	.3, .5, .7	1,925	1,947	1,960	(*b*)	....
57		8	+ 25	579.715	578.855	.860	1 B, 5 A	.3, .5, .7	2,064	2,058	2,049	−15	....
58		9	+ 68	579.700	578.824	.876	1 B, 5 A	.3, .5, .7	2,013	2,027	2,055	+12	....
59		14	+ 32	579.707	578.819	.888	1 B, 5 A	.3, .5, .7	2,059	2,052	2,048	−11	....
60		22	+ 73	579.592	578.753	.839	1 B, 5 A	.3, .5, .7	2,049	2,032	2,035	−14	....
61	Oct.	10	−267	578.911	578.105	.806	1 B, 5 A	.3, .5	1,809	1,872	1,826	+17	579.527
62		11	−133	579.079	578.247	.832	1 B, 5 A	.3, .5, .7	1,900	1,931	1,890	−10	579.733
63		13	−246	578.939	578.137	.802	1 B, 5 A	.3, .5, .7	1,845	1,902	1,837	− 8	579.554
64		14	+255	579.484	578.586	.898	1 B, 5 A	.3, .5, .7	2,092	2,033	2,057	−35	580.177
65		16	−276	578.797	577.994	.803	1 B, 5 A	.3, .5, .7	1,803	1,868	1,803	0	579.407
66		17	+ 37	579.373	578.507	.866	1 B, 5 A	.3, .5, .7	1,987	1,979	1,985	− 2	580.076
67		18	− 35	579.221	578.360	.861	1 B, 5 A	.3, .5, .7	1,944	1,952	1,940	− 4	579.892
68		19	+ 50	579.343	578.483	.860	1 B, 5 A	.3, .5, .7	1,976	1,964	1,982	+ 6	579.991
69		20	+105	579.309	578.419	.890	1 B, 5 A	.3, .5, .7	2,004	1,979	1,989	−15	579.948
70		23	−194	578.925	578.094	.831	1 B, 5 A	.3, .5, .7	1,830	1,875	1,845	+15	579.580
71		27	+ 72	579.265	578.379	.886	1 B, 5 A	.3, .5, .7	1,988	1,972	1,972	−16	579.986
72		27	+ 46	579.176	578.327	.848	1 B, 5 A	.3, .5, .7	1,969	1,958	1,951	−18	579.881
73		28	+ 12	579.337	578.477	.861	1 B, 5 A	.3, .5, .7	1,946	1,944	1,973	+27	580.004
74		28	+108	579.390	578.513	.877	1 B, 5 A	.5, .3	1,963	1,938	2,005	+42	580.090
75	Nov.	1	+294	579.595	578.677	.918	1 B, 5 A	.3, .5, .7	2,072	2,004	2,089	+17	580.381
76		1	+475	579.596	578.662	.934	1 B, 5 A	.3, .5, .7	2,125	2,014	2,131	+ 6	580.452
77		3	+205	579.342	578.383	.959	1 B, 5 A	.3, .5, .7	2,049	2,001	2,018	−31	580.126
78		15	− 86	578.921	578.108	.813	1 B, 5 A	.3, .5, .7	1,857	1,877	1,871	+14	....
79		16	0	578.960	578.125	.845	1 B, 5 A	.3, .5, .7	1,876	1,876	1,898	+22	579.652
80		17	−178	578.429	577.665	.764	1 B, 5 A	.3, .5, .7	1,740	1,782	1,755	+15	579.040
81		21	−202	578.691	577.891	.800	1 B, 5 A	.3, .5, .7	1,803	1,850	1,800	− 3	579.312
82		23	+198	579.044	578.154	.890	1 B, 5 A	.3, .5, .7	1,952	1,906	1,960	+ 8	579.752
83		24	− 5	578.978	578.099	.879	1 B, 5 A	.3, .5, .7	1,929	1,930	1,901	−28	579.578
84		27	− 27	578.876	578.074	.802	1 B, 5 A	.3, .5, .7	1,865	1,871	1,877	+12	579.503
85		28	−120	578.898	578.085	.813	1 B, 5 A	.3, .5, .7	1,854	1,882	1,859	+ 5	579.492
86		29	−170	578.817	578.012	.805	1 B, 5 A	.3, .5, .7	1,814	1,854	1,832	+18	579.439
87	Dec.	1	−314	578.719	577.978	.741	1 B, 5 A	.3, .5, .7	1,779	1,852	1,779	− 0	....
88		2	− 76	579.110	578.323	.787	1 B, 5 A	.3, .5, .7	1,908	1,925	1,909	+ 1	579.714
89		4	+327	579.237	578.370	.867	1 B, 5 A	.3, .5, .7	2,009	1,933	2,028	+19	579.950
90		6	+240	579.182	578.338	.844	1 B, 5 A	.3, .5, .7	1,988	1,932	1,996	+ 8	579.971

NOTE.—Equation derived from 76 observations. Discharge=152,500+19,030 (Gauge G. T. R. above 577)+23.3 (wind constant).

As a mean of 7 months' readings water surface at G. T. R. is 0.77 foot below that at Sand Beach; range of 10 day means 0.72 Sept. 21–30 to 0.82 May 11–20.

Results marked *a*, *b*, and *c* were not used in computing the relation of discharge to gauge for the following reasons: *a*, but one meter used in discharge; *b*, fluctuations of water surface during discharge more than 0.8 foot; *c*, elevation water surface uncertain. Results marked *d*, gauge record G. T. R. burned; elevations given are deducted from Sand Beach and "Dry dock."

RELATION OF DISCHARGE AND STAGE.

Effect of wind.—Table No. 12 exhibits the results of the ninety measurements of discharge made in 1899. Upon platting the observed discharges with reference to stage at G. T. R. it was found that a straight line could be drawn through the platted points in such a way as to leave nearly all the observations taken when the wind was from a northerly direction on one side of the line and the observations taken when a southerly wind prevailed on the other side of the line. It was therefore plain that the effect of wind on discharge-gauge relation was very great, a north wind increasing the discharge in a much greater ratio than it increased the gauge height. It might be considered at first thought that in so many determinations the effect of wind would be so compensated as not to affect the resulting relation of discharge to stage, but since a northerly wind resulted in high stage, and, vice versa, northerly winds were in the ascendency at the higher stages and southerly winds at the lower stages. It is therefore evident that to compute the discharge curve without making a correction for wind effect would result in too great a change in discharge for a given change in stage.

The axis of Lake Huron lies approximately in a north and south line. A northerly wind, therefore, drives the water to the foot of the lake, creating an abnormal slope just above the outlet and increasing the velocity of approach at the head of the river; the discharge is therefore increased beyond that shown by a gauge placed directly at the outlet. In a northerly wind the water surface between Sand Beach and the foot of the lake is a curved surface, convex upward. The water level to which the discharge would approximately correspond is the level of the highest point of this surface, though this relation would doubtless be modified by the direct action of the wind on the water surface and by other considerations.

An attempt was made at first to evaluate the wind effect by a study of the water stage alone; that is, by finding a normal water surface by the method of bi-five day means and taking the difference between the actual and the normal stage as a measure of the wind effect. But this did not result satisfactorily, and it was found necessary to introduce in the equations a term expressing the effect as a direct function of the wind velocity. Through the courtesy of the Weather Bureau officials we were enabled to consult for this purpose the records of hourly wind movement at Port Huron which were very satisfactory. As the Port Huron office did not have an anemoscope the records of the wind directions were derived from the bi-daily readings of the Weather Bureau supplemented by the notes taken at the discharge section. The directions are therefore not so accurately known.

To derive a constant to which the effect of the wind should be proportional, it is considered the effect of the wind would vary as the square of the velocity and that only the component in a north or south direction would have any effect on the discharge. Each day on which a discharge measurement was taken was therefore treated as follows: The velocities and directions for each hour when observations were in progress were first tabulated. The squares of the velocities were then taken out and the north or south component of each of these squares was obtained, the northerly components being considered plus and the southerly components minus. Each of these quantities may be considered the wind constant for the hour to which it applies, and the algebraic mean of the values for the several hours gave the wind constant for the discharge measurement of the day. It is seen that a wind from the north blowing at a rate of 10 miles per hour throughout the day would have a constant of +100. If a wind of the same velocity blew from the southwest the wind constant would be −71. The wind constant derived for each discharge is given in the table, and it is seen that the values range from −409 to +475.

Discharge equations.—In making the least square adjustment each measurement gave an observation equation of the form $x=a+by+cz$, where x is the discharge in hundred cubic feet per second, y is the elevation of water surface at G. T. R. above 577 feet, and z is the wind constant, a, b, and c being unknown coefficients. The range in stage covered by the observations is so small that the use of an equation of the second degree did not seem warranted. In deriving the equation expressing the discharge-stage relation 14 observations were omitted from the computation. Eleven of these were taken with a single meter, and were therefore not of equal value with the later observations taken with 2 meters and covering about the same stage. One observation, No. 56, was omitted on account of the extreme fluctuation of the water level during the measurement, amounting to over eight-tenths of a foot, the observed discharge being much too low. Two observations were omitted on account of uncertainty in water level at G. T. R. On August 18 the gauge at G. T. R. was burned with the roll containing the water level record for the month. The water level at this point for 8 measurements, August 3 to 16, had to be deduced from the records at Sand Beach and at Dry Dock. It chanced that the water levels were quite steady

during this interval and the G. T. R. level as deduced from Sand Beach, above the gauge, agreed well with that deduced from the self-register at the section, except in one case, August 12. All of these measurements then, except the one taken on August 12, were included in the computations. This gave 70 observations for the adjustment.

The solution of the normal equations gave the following values for the coefficients:

$$a=1525 \qquad b=190.3 \qquad c=+0.233 \qquad \text{or}$$
$$x=1525+190.3y+0.233z \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (\text{eq. } 1)$$

If we express x in cubic feet per second we have

$$Q=152500+19030\ (\text{Gauge G. T. R.} -577.0) +23.3\ (\text{wind constant}) \quad . \quad (\text{eq. } 2)$$

that is, the computed discharge for a gauge height at G. T. R. of 577 feet above mean tide at New York (by levels of 1877) is 152,500 cubic foot-seconds; the increment on discharge per foot of rise in water surface at G. T. R. is 19,030 cubic foot-seconds; and the effect of the wind on the discharge is 23.3 cubic foot-seconds multiplied by the wind constant obtained as already explained. A northerly wind of 10 miles per hour would thus increase the discharge 2,330 cubic foot-seconds beyond that due to increased water stage at G. T. R. By substituting the values for y and x we obtain the "computed discharge" as given in Table No. 12 for each measurement. The differences between the computed and observed values, or the residuals, are also taken out. It is seen that the greatest residual is 4,200 cubic foot-seconds. The probable error of a single observation is 1,320 cubic foot-seconds. By subtracting from each observed value of the discharge 23.3 times the wind constant with due regard to sign we obtain the values of discharge given in the column headed "Discharge corrected for wind." These quantities represent the observed relation of discharge to gauge and contain all of the errors of observation, but are independent of wind effect. These values of discharge are plotted on Plate XI.

It is evident that in any general discussion of the outflow of Lake Huron the wind factor need not be taken into account except in dealing with limited periods in which the effect of wind is not compensated. In other words, a continuous measurement of the discharge carried over several years would nearly eliminate this factor. The necessity of introducing it in discussing the observations here is due to the fact that the measurements are for but one season and that the extremes of stage were caused partly by wind. It is also clear that this value of wind effect will not hold for the water level at any other point than the one for which it is deduced, because what appears as velocity of approach at G. T. R. is partially shown by stage as we go upstream. If we omit the wind factor then, we have the equation

$$Q=152500+19030\ (\text{Gauge G. T. R.}-577.0) \quad . \quad . \quad . \quad . \quad (\text{eq. } 3)$$

expressing the simple relation between discharge and stage.

The difference between the water level at Sand Beach and that at G. T. R., as given by water-level records of May to November, inclusive, 1899, has a mean value of 0.77 foot. While this slope is not constant, its variation with stage is not great for water stages within the limits of observation, and we may transfer the discharge curve to Sand Beach levels by a direct application of this fall, giving

$$Q=152500+19030\ (\text{Gauge Sand Beach} -577.77) \qquad \text{or}$$
$$Q=194950+19030\ (\text{Gauge Sand Beach} -580,00) \quad . \quad . \quad . \quad (\text{eq. } 4)$$

For 28 observations taken after October 10 we have the record of stage above the light-house. The discharge-gauge relation of these 28 measurements referred to this gauge was therefore deduced in the same manner as detailed above for 76 measurements referred to G. T. R. The resulting equation was found to be

$$Q=152400+19060\ (\text{Gauge Light-House} -577.67) +18.7\ (\text{wind constant}) \quad . \quad (\text{eq. } 5)$$

with a probable error of a single observation of 1,240 cubic foot-seconds. The fall from this gauge to G. T. R. was found to have a mean value of 0.67 foot from the data so far collected. The agreement of this equation with the result deduced from 76 observations referred to gauge G. T. R. is so close as to show it to be accidental. It is seen that the wind factor in the last equation is less than the one found when the results were deduced with reference to G. T. R. gauge. As already intimated, if the gauge readings were taken further upstream, this factor would decrease still further. To transfer this equation to Sand Beach it is only necessary to drop the term dealing with wind, and apply the indicated difference of 0.1 foot between Sand Beach and Light-House gauges, giving the equation

$$Q=152400+19060\ (\text{Gauge Sand Beach} -577.77) \qquad \text{or}$$
$$Q=194900+19060\ (\text{Gauge Sand Beach} -580.00) \quad . \quad . \quad . \quad (\text{eq. } 6)$$

Since equation (4) has been derived from 76 observations it will be used as the discharge equation. In using this equation the fact must be borne in mind that the range in stage covered by the observations is only about 1.3 feet, or between 579.5 and 580.8 for Sand Beach gauge, and that values given by the equation outside of thes elimits of stage are only approximations. Even within these limits it will be shown that the discharge is not dependent alone upon the stage of Lake Huron, and it is very unlikely that the curve of gauge relation is in reality a straight line.

Results of early discharge measurements.—In 1867 the measurement of the discharge of the lake outlets was inaugurated by General Raynolds and observations were made upon the St. Clair River at St. Clair for parts of three seasons by Assistant D. F. Henry. The methods employed were not such as to give the most accurate results, principally for the reason that in general only a few stations were occupied in a day. The mean result of the season's work, however, must eliminate many of the errors which would be shown by a comparison of the daily discharges, and we have therefore given the season averages in Table No. 13. During the season of 1867 double floats were used, and in the two succeeding years current meters were employed. Comparisons of the results by float and by meter at different depths indicated a considerable difference between the two methods, and in the report of 1870 a table is given by which the discharge given by floats may be made to correspond with that given by meters. In Table No. 13 the results of 1867, which were taken with floats, have been reduced according to the tables in the Report of 1870, as indicated in the remarks; otherwise no changes have been made in reported results. The mean level of Lake Huron is the mean of the two or three months during which observations were made, and not the mean level for the days on which observations were actually in progress. As indicating the range in stage during a season it may be said that in 1868 the mean lake level in July was 581.16 and in September 580.58.

TABLE No. 13.—*Results of measurements of discharge in 1867–1869.*

	Mean elevation, Huron.	Discharge by measurement.	Discharge by equation, 1899.	Difference.
June, July, 1867	581.66	233,726	226,540	*a* +7,186
June, July, 1867	581.66	221,027	226,540	*b* −5,513
July, August, September, 1868	580.85	216,192	211,130	+5,062
July, August, 1869	581.45	217,658	222,540	−4,882

a Results obtained by double floats in 1867.
b Above result reduced according to tables given in Report of 1870, showing difference between results by floats and by meters applied to each division of the river.

DISCHARGE OBSERVATIONS BY INTEGRATION METHOD.

At the end of the season's work a few measurements of discharge were made by the "flanking" or "integration" method. The catamaran was made fast to the port side of the tug near the bow and was moved slowly along the section from one side of the river to the other. Two meters were used; No. 1B was placed at 10 feet depth and remained at the same depth throughout; meter No. 5A was run at about 17 feet depth between stations 8 and 20 and at about 7 feet depth for the other stations, the change in depth being made quickly just after reaching the deep water and just before reaching the shallow water—that is, on the channel sides of Stations 8 and 20. Simultaneous readings were taken on the two meters at thirty-second intervals and at the time of passing station points. By this method a discharge was measured in about forty minutes, the time of passing from one station to the next being about two minutes.

In the reduction of the observations the same general methods were used as in computing other discharges except that a partial area was considered as extending from one station point to the next, instead of 50 feet on either side of a station. The determination of the mean velocity was somewhat more complicated. The velocity recorded by the meter is the resultant of the movement of the boat across the stream and of the water across the section. The latter component was scaled from a diagram on which the movement of the boat and the velocity given by the meter were accurately platted as base and hypothenuse, respectively, of a right triangle. A correction was also applied to this observed velocity for the amount which the boat had moved up or down stream while passing from one station to another, or, rather, the net amount of such movement as indicated by the observed position of the meters with respect to the section for two consecutive stations. This correction was comparatively small, and had it not been made the error would have been in the nature of a compensating one.

Having obtained the observed velocity between two stations, it was reduced to mean velocity by the application of the mean of the coefficients from the vertical curves of the two stations. The mean velocity between two stations multiplied by the water area included between them gave the partial discharge.

TABLE No. 14.—*Summary of discharge measurements by integration method.*

Number.	Date.	Time.	Wind Const.	Water surface above mean tide, New York City.			Discharge, cubic feet per second.				Discharge by equation.[a]	Difference.
				G. T. R.	Dry dock.	Difference.	Meter 5 A.	Meter 1 B.	Mean.	Mean corrected for wind.		
	1899.											
1	Dec. 7	9.37–10.14	−361	577.789	577.104	0.685	157,917	155,177	156,547	164,958	167,515	+ 2,557
2	7	10.20–10.51	−400	577.942	577.223	.719	165,027	163,961	164,494	173,814	170,426	− 3,388
3	8	8.21– 8.54	−159	579.017	578.110	.907	196,415	194,357	195,386	199,091	190,884	− 8,207
4	8	9.02– 9.44	−204	578.916	578.196	.820	190,972	189,126	190,049	194,802	188,961	− 5,841
5	8	9.54–10.33	−181	578.853	578.000	.853	191,602	189,474	190,538	194,755	187,763	− 6,992
6	8	10.54–11.34	−159	578.816	577.984	.832	194,864	192,433	193,648	197,353	187,058	−10,295
7	8	12.46–13.36	− 90	578.907	578.036	.871	197,140	196,454	196,797	198,894	188,790	−10,104
8	8	14.05–14.40	− 64	579.112	578.196	.916	202,919	202,092	202,506	203,997	192,691	−11,306
9	8	14.42–15.28	− 38	579.124	578.226	.898	199,443	198,314	198,878	199,763	192,920	− 6,843
10	9	8.00– 8.45	−139	578.516	577.695	.821	181,349	182,550	181,950	185,189	181,349	− 3,840
11	9	9.28–10.06	−102	578.471	577.652	.819	182,407	182,944	182,676	185,053	180,493	− 4,560

[a] Discharge=152,500+19,030 (G. T. R. Gauge above 577).

The results of these discharge measurements are given in Table No. 14, where they are compared with the discharge indicated by the equation derived from the regular observations. It is seen that in general the discharge by the integration method is too great. This has been the experience elsewhere with this method. The cause may be sought in the irregular movements of the meter, it being impossible to keep the boat exactly on the section. It is possible, also, that the tug wheel may have an appreciable effect on the velocity of the water passing the meter.

EFFECT OF TUG WHEEL ON VELOCITIES GIVEN BY INTEGRATION.

Method.—A few experiments were made to determine what effect the tug wheel has upon the velocities given by the meter when the catamaran is made fast to the tug, as in taking discharge by integration. These experiments are given in Table No. 15. In the trials at Station 1+47 the catamaran and tug were made fast to the piles so that they were held closely in position, while the tug wheel was working much harder than necessary to hold the catamaran up in the current at this point, and in some cases harder than would be required at the high-velocity stations. In the experiments at Station 13 the tug was working a little harder than required to hold the catamaran in the current. It was necessary to keep out both head and side anchors to hold in position when the tug ceased working. These anchor lines were partially slacked when tug was in use, but the side line still pulled downstream somewhat on the catamaran.

The experiments at Station 1+47 gave very little indication of the tug wheel having any effect on the meter except when working at the highest speed. At Station 13 some effect of tug wheel appears to be indicated, but the current was so variable as to make the conclusion extremely uncertain.

TABLE No. 15.—*Experiments on effect of propeller wheel on current velocity measured near the tug.*

Time of day.	Station.	Depth meter.	Number revolutions tug wheel per minute.	Observed velocity 1 B.	By meter 5 A.	December 9, 1899, number of seconds meter run.
10.34	1+47	8.8	None.	1.93	1.93	300
10.40	1+47	8.8	50	1.97	1.97	300
10.47	1+47	8.8	76–88	1.96	1.97	300
10.53	1+47	8.8	122–134	2.04	2.04	300
11.00	1+47	8.8	None.	1.91	1.89	300
12.04	1+47	8.8	None.	1.71	1.74	300
12.10	1+47	8.8	96–104	1.72	1.78	300
12.16	1+47	8.8	124–128	1.73	1.78	300
12.21	1+47	8.8	None.	1.71	1.75	300
2.09	13	16.8	None.	3.71	3.70	300
2.19	13	16.8	(*a*)	3.60	3.58	330
2.25	13	16.8	(*a*)	3.84	3.80	360
2.36	13	16.8	None.	3.54	3.56	300
2.51	13	16.8	None.	3.63	3.63	300
3.00	13	16.8	(*a*)	3.72	3.72	300

a Outfit held in position by tug. See text.

Transverse curves.—Under the head of vertical curves attention has been called to the difficulty of obtaining a true curve with a single meter. The same difficulty exists when we attempt to determine the distribution of velocities along a line transverse to the current, and as it is impracticable to apply the multiple-meter principle to the whole width of the river we must depend upon a large number of results to give an idea of the mean transverse curve. Accordingly, twelve measurements, Nos. 49 to 60, have been combined to bring out the form of the transverse curve. In each of these measurements four velocities were observed at each station, two at three-tenths, one at five-tenths, and one at seven-tenths depth. The mean velocity corresponding to each observed velocity having been taken out as shown in Table 11, where the reduction of measurement No. 59 is illustrated, the mean of the twelve velocities derived from the observed three-tenths depth velocity is taken out for each station. Likewise the mean of the twelve means derived from the observations at each of the other depths is obtained, and the resulting means are shown in the first four lines of Table No. 16. The mean of the four results in each column gives for each station the mean velocity deduced from forty-eight observations, as shown in the fifth line of the table. These velocities platted as ordinates at each station give the transverse curve of mean velocities shown in fig. 2 of Plate XII. No practical use was made of this curve in the reduction of the observations. It is of interest to note that between Stations 4 and 20 the mean velocity changes slowly.

TABLE No. 16.—*The means of the deduced mean velocities for twelve measurements, Nos. 49 to 60, inclusive.*

[Meter 1 B at 0.3 depth; 5 A at 0.5 and 0.7 depth.]

Prop. depth.	Station 1.	Station 2.	Station 3.	Station 4.	Station 5.	Station 6.	Station 7.	Station 8.	Station 9.	Station 10.	Station 11.
0.3	0.660	1.576	2.307	2.852	3.015	3.061	3.240	3.393	3.499	3.598	3.695
.5	0.620	1.618	2.361	2.768	3.028	3.037	3.238	3.378	3.492	3.572	3.670
.3	0.664	1.567	2.295	2.801	2.951	3.148	3.288	3.321	3.498	3.508	3.665
.7	0.618	1.663	2.399	2.753	2.948	3.138	3.277	3.291	3.534	3.518	3.634
Mean.	0.640	1.606	2.340	2.794	2.986	3.096	3.261	3.346	3.506	3.549	3.666

Prop. depth.	Station 12.	Station 13.	Station 14.	Station 15.	Station 16.	Station 17.	Station 18.	Station 19.	Station 20.	Station 21.
0.3	3.772	3.994	4.004	3.942	3.796	3.738	3.628	3.492	3.168	1.842
.5	3.768	3.962	4.000	3.908	3.794	3.710	3.580	3.462	3.123	1.902
.3	3.739	4.017	3.945	3.921	3.777	3.707	3.679	3.502	3.218	1.778
.7	3.750	3.983	3.985	3.892	3.780	3.745	3.565	3.492	3.248	1.863
Mean.	3.757	3.989	3.984	3.916	3.787	3.725	3.613	3.487	3.189	1.846

TABLE No. 17.—*Velocities deduced from table No. 16.*

Prop. depth.	Station 1.	Station 2.	Station 3.	Station 4.	Station 5.	Station 6.	Station 7.	Station 8.	Station 9.	Station 10.	Station 11.
Surface	0.65	1.62	2.62	3.05	3.32	3.31	3.55	3.71	3.75	3.75	3.92
0.1	0.68	1.71	2.68	3.09	3.39	3.40	3.64	3.84	3.91	3.93	4.03
.2	0.70	1.77	2.67	3.07	3.33	3.43	3.59	3.79	3.89	3.87	3.97
.3	0.74	1.79	2.59	3.00	3.29	3.38	3.57	3.72	3.83	3.85	3.92
.4	0.72	1.77	2.49	2.96	3.22	3.33	3.49	3.64	3.76	3.78	3.86
.5	0.69	1.73	2.40	2.88	3.12	3.24	3.39	3.54	3.67	3.69	3.80
.6	0.65	1.68	2.32	2.81	3.01	3.15	3.28	3.40	3.55	3.59	3.70
.7	0.61	1.58	2.21	2.71	2.88	3.02	3.13	3.16	3.40	3.45	3.53
.8	0.56	1.46	2.07	2.56	2.69	2.84	2.96	2.88	3.16	3.29	3.34
.9	0.50	1.29	1.89	2.36	2.39	2.52	2.67	2.56	2.81	2.98	3.03
Bottom	0.43	1.04	1.54	1.89	1.89	2.03	2.17	2.05	2.26	2.40	2.38

Prop. depth.	Station 12.	Station 13.	Station 14.	Station 15.	Station 16.	Station 17.	Station 18.	Station 19.	Station 20.	Station 21.
Surface	4.04	4.33	4.32	4.24	4.16	4.04	3.99	3.82	3.47	2.07
0.1	4.19	4.43	4.42	4.37	4.28	4.16	4.09	3.95	3.62	2.11
.2	4.14	4.37	4.36	4.32	4.17	4.15	4.03	3.91	3.59	2.12
.3	4.07	4.29	4.28	4.23	4.15	4.07	3.96	3.82	3.52	2.09
.4	4.01	4.21	4.19	4.14	4.06	4.00	3.90	3.74	3.43	2.03
.5	3.92	4.14	4.09	4.05	3.97	3.90	3.79	3.64	3.34	1.96
.6	3.80	4.04	3.98	3.93	3.83	3.76	3.68	3.52	3.22	1.87
.7	3.65	3.87	3.83	3.80	3.64	3.58	3.50	3.38	3.07	1.74
.8	3.45	3.69	3.69	3.59	3.41	3.36	3.22	3.12	2.88	1.60
.9	3.14	3.38	3.41	3.26	3.08	3.00	2.84	2.76	2.52	1.42
Bottom	2.46	2.65	2.74	2.56	2.38	2.33	2.20	2.12	1.93	1.10

To the mean velocities in the fifth line of Table No. 16 we have but to apply for each station the ratios of observed to mean velocity to obtain the distribution of the velocities in the vertical at each station. Table No. 17 gives the result of this reduction, showing the velocity at each tenth of depth at each station. In fig. 1 of Plate XII each velocity is platted at the point in the actual cross section where it occurs, and contours of equal velocity for each 0.2 foot-second change are drawn. This gives a very clear idea of the distribution of the velocities throughout the cross section. It is of interest to notice that the contour following the mean velocity of the section passes quite near the bottom in the stations of high velocity. The inclination of the contours toward the center of the section as they approach the surface is due to the peculiarity of the vertical curves, which has been attributed to the effect of the catamaran in retarding the velocity at the surface. The slow rate of change of velocity near the center of the section and the rapid rate of change near the banks are clearly brought out. If the distribution of velocities here indicated were constant, an observed velocity at one point in the cross section would be sufficient to determine the discharge, but there are of course very important momentary as well as daily changes in distribution; the figure only shows the mean conditions deduced from a combination of twelve discharge measurements with the mean vertical curves.

SLOPE AT THE HEAD OF ST. CLAIR RIVER AND ITS EFFECT ON THE DISCHARGE.

With a fixed regimen the fall at the head of the river will vary approximately with the stage of Lake Huron. This dependence of slope upon stage, however, is subject to several important modifications, as will be shown.

During the season of 1899 several gauges were maintained along that portion of the river which is above the discharge section. In Table No. 18 are given the monthly mean elevations of water surface at these points, and at Roberts Landing, St. Clair Flats, Windmill Point, and Amherstburg. The location of the gauges at the head of the river are indicated on Plate I.

TABLE No. 18.—*Monthly mean elevations of water surface at Sand Beach and points on St. Clair and Detroit rivers.*

Month.	Sand Beach.	G. T. R.		Waterworks.		Kendall's.	
		Water surface.	Fall.	Water surface.	Fall.	Water surface.	Fall.
1899.							
May	579.95	579.15	0.80	578.92	1.03	578.62	1.33
June	580.35	579.58	.77	579.30	1.05	579.00	1.35
July	580.64	579.86	.78	579.62	1.02	579.29	1.35
August	580.55	*a*[579.81	.74]	579.57	.98	579.22	1.33
September	580.35	579.61	.74	579.36	.99	579.10	1.25
October	579.94	579.16	.78	578.91	1.03	578.77	1.16
November	579.80	579.03	.77	578.82	.98	....	....
December	579.61	578.84	.77	578.65	.96	....	....

Month.	Sand Beach.	Black River.		Dry dock.		Roberts Landing.	
		Water surface.	Fall.	Water surface.	Fall.	Water surface.	Fall.
1899.							
May	579.95	578.59	1.36	578.32	1.63	....	....
June	580.35	578.97	1.38	578.68	1.67	....	....
July	580.64	579.26	1.38	578.98	1.66	576.28	4.36
August	580.55	579.19	1.36	578.95	1.60	576.26	4.29
September	580.35	579.07	1.28	578.76	1.59	576.11	4.24
October	579.94	578.74	1.20	578.31	1.63	575.72	4.22
November	579.80	578.54	*b*1.26	578.18	1.62	575.54	4.26
December	579.61	....	....	578.02	1.59	575.47	4.14

Month.	Sand Beach.	St. Clair Flats.		Windmill Point.		Amherstburg.	
		Water surface.	Fall.	Water surface.	Fall.	Water surface.	Fall.
1899.							
May	579.95	575.01	4.94	574.63	5.32	572.51	7.44
June	580.35	575.28	5.07	574.96	5.39	572.66	7.69
July	580.64	575.45	5.19	575.23	5.41	572.66	7.98
August	580.55	575.39	5.16	575.13	5.42	572.49	8.06
September	580.35	575.08	5.27	574.85	5.50	572.07	8.28
October	579.94	574.78	5.16	574.59	5.35	571.89	8.05
November	579.80	574.65	5.15	574.42	5.38	571.77	8.03
December	579.61	574.59	5.02	574.04	5.57	571.30	8.31

a Record from August 1-19 destroyed by fire. Completing the month's record by deducing level from Sand Beach and dry dock gives 579.81 as the probable monthly mean.
b Mean for twenty-one days.

The staff gauge at Sand Beach was read tridaily; at G. T. R. a self-register was located; the waterworks gauge was read twice daily by the waterworks officials; Kendall's gauge was also read twice daily from May to October, inclusive, and the levels for mouth of Black River were deduced from these by subtracting 0.03 foot. The gauge at mouth of Black River was read but once a day during November and on some days the gauge was not read at all. The fall indicated is the mean of that existing on the days when readings were actually taken. At Dry Dock, near the gauging section; Roberts Landing, at head of delta; Windmill Point, at head of Detroit River, and Amherstburg, at the foot of Detroit River, the results are from the self-registers, while at St. Clair Flats the results are from tridaily readings of staff gauge. Roberts Landing gauge was not started until July 1, and its record is therefore incomplete.

All of these results are platted on Plate XIII, and it is evident that no simple relation of the fall at the head of St. Clair River to the stage of Lake Huron can be determined from a study of one season's observations. It appears that when the lake is rising the fall at the head is greater for the same stage than when the water is receding. That is, as a general rule, subject to many exceptions, the gauge near the lake is ahead of the gauge at the section. This condition prevailed at the head of the river during the past season, although the fall in the entire river, as shown by the Flats gauge, would tend to reverse it. This will be clear if we compare the conditions in June and September. In these two months the mean lake level was the same, but in June the lake was rising rapidly, while in September it was falling rapidly. In

the latter month the fall in the entire river was 0.02 foot greater than in June, while the fall from the lake to gauge dry dock was 0.06 foot less.

In December, 1898, two discharge measurements were made when the slope at the head of the river was much below the normal, due to ice effect in the lower river. On December 17, with a stage at G. T. R. of 578.74, the fall at dry dock was only 0.44 foot, or about 0.39 foot below the normal, while the measured discharge, corrected for wind, was 138,000 cubic foot-seconds, or 47,600 cubic foot-seconds less than normal for that stage. Likewise on December 19 the discharge was 166,000 cubic foot-seconds, or 15,500 cubic foot-seconds less than normal when the fall was about 0.12 foot below the normal. It would appear from this that an artificial change in fall of 0.01 foot between these two gauges would result in a change of over 1,200 cubic foot-seconds in discharge. This measured effect seems to be very large, yet if we consider the channel from G. T. R. to dry dock we find the approximate characteristics: Mean area, 55,000; hydraulic radius, 30, and length 21,600 feet; and if in the formula $v=c\sqrt{RS}$ we put $c=100$, we find a change in fall of 0.01 foot to give a change in v of 0.021 foot-seconds, which, multiplied by the area, 55,000 square feet, gives a change in Q of 1,155 cubic foot-seconds.

Some evidence of this effect of slope on discharge may be traced in the residuals of the observed discharge. In June, with a rapidly rising lake, the fall at the head of the river and the observed discharge were above the normal, while in September, with a falling stage, both were below the normal. The effect of the other conditions and the errors of observation, however, are too great to establish a satisfactory relationship by a detailed study of these small irregularities in slope and discharge.

The point which it is desired to bring out here is that the discharge of St. Clair River is not a function of the elevation of Lake Huron alone; but that it is modified by the slope at the head of the river. It has already been shown that the slope at the head of the river does not closely follow the stage when the conditions of a single season are considered. But it will be pointed out that the stage of Lake Huron is really a major controlling factor in this slope, although it is probably affected by the elevation of Lake Erie. It is because of the back water effect of Lake Erie, and the fact that the equilibrium of stage and slope is disturbed yearly by ice effect, that we speak of the slope modifying discharge rather than the discharge as fixing the slope.

The existing data concerning the fall at the head of the river in previous years are very meager. There is some reason to suppose that in the early part of the century the fall was greater than at present. In 1837 Mr. William R. Hopkins, a civil engineer, remarks as follows: "The fall is but 16 inches in the 3 miles (from Lake Huron to mouth of Black River). Those who have leveled it in summer state it to be 2½ feet, and I have no doubt this is the fact, as vessels are frequently detained at the mouth of Black River twenty days for want of a strong wind to carry them up the rapids, and 20 or 30 sail are often waiting at a time."

The occasional water levels on record from 1819 to 1838 also indicate a greater fall in the St. Clair and Detroit rivers than that existing at present, and it is probable that the head of the St. Clair River had its due proportion of this greater fall. As these early water-level records, however, are usually single readings, no detailed conclusions can be drawn. For 1840, monthly means have been published for Michigan and Erie which show a fall of from 6 to 8 feet between the two lakes, which is less than at present, but observations at the Detroit waterworks during the same year give a lower level for some months than those given for Lake Erie, showing that these early records are more or less unreliable.

In 1854 systematic records were entered upon, and from that time to the present, with only occasional interruptions, we have a continuous record of the levels of Lake Michigan-Huron, Lake Erie, and the Detroit River. The distribution of the total fall in different years is still in doubt, for we have not been able to find any early water levels of the St. Clair River just below the rapids, although it is known that a series was taken extending over several years.

TABLE No. 19.—*Mean elevation of water surface at mouth of Black River.*

[From observations made during several months from 1889 to 1899.]

No.	Year.	Month.	Number months read.	Lake Huron at Sand Beach.	Mouth Black River.	Fall.
1	1889	June-August	3	581.19	579.70	1.49
2	1891	May-August	4	580.40	578.90	1.50
3	1891	September-November	3	579.79	578.45	1.34
4	1892	May-August	4	580.19	578.99	1.20
5	1892	October-November	2	579.98	578.60	1.38
6	1893	August-September	2	580.56	579.36	1.20
7	1897	June-September	4	580.28	579.00	1.28
8	1897	October-December	3	579.61	578.50	1.11
9	1898	April-May	2	580.06	578.71	1.35
10	1899	May-August	4	580.37	579.00	1.37
11	1899	September-November	3	580.03	578.78	1.25

Beginning with 1889, there are on record a few water-level observations taken in connection with the dredging operations in Black River and at its mouth. These observations, together with those made since May, 1899, by the Lake Survey, are summarized in Table No. 19. Upon platting the observed elevation at mouth of Black River with reference to the level of Lake Huron (Plate XIV, fig. 2), it is found that while the relation of fall to stage is indicated, it is not always closely maintained. For instance, the fall for 1891 seems to be above the normal, while in 1893 it is below. We may gain a general idea of the relationship, however, by obtaining the mean curve. Giving each result a weight unity, we find the equation.

Water level mouth Black River=577.88 +.84 (Huron above 579), or $x=1.12+.16\,y$, expresses the relation of fall to Huron level, where x is the fall to Black River and y is the elevation of the lake above 579.

We may arrive at this relation by a consideration of the hydraulic conditions if we assume that the discharge follows the level of Lake Huron and that the equation $V=C\sqrt{RS}$ may be applied to short reaches of the river in which the assumption of uniform flow will be not too violent. For this purpose we have computed the area of cross section of the river at points about 1,000 feet apart near the head and about 2,000 feet apart from Black River to the section gauge; these areas are shown on Plate I, with the form of the characteristic sections. On Plate XV are shown the width of the river; the profile of the bed of the river following the channel of greatest depth; the profile of the mean bottom—that is, the depth each section would have were it of uniform depth across the section, and the approximate profile of the water surface when Lake Huron is at 580-foot stage. The river is then divided into four reaches, so selected that the slope approaches uniformity throughout each reach. The first is that portion of the river from staff gauge No. 1 to gauge G. T. R.; the second extends from G. T. R. to waterworks; the third from waterworks to Kendall's gauge, just above Black River, and the fourth from this point to gauge dry dock, above the gauging section.

The gauge records of 1898–99, with the section areas mentioned, give the following characteristics of the several reaches when Lake Huron is at 580 feet:

Reach.	Length. l.	Mean area. a.	Mean width. w.	Mean wet perim. p.	Mean depth. d.	Fall in feet. h.
Above staff gauge No. 1						.44
No. 1, gauge No. 1 to G. T. R	2,900	37,650	1,015	1,023	37.1	.33
No. 2, G. T. R. to waterworks	3,200	42,950	1,375	1,385	31.2	.25
No. 3, waterworks to Kendall's	4,200	48,910	1,592	1,604	30.7	.25
No. 4, Kendall's to dry dock	14,300	59,050	2,167	2,180	27.3	.33

With the discharge under these conditions 194,950 c. f. s., we may find the following:

Reach.	Hydr. rad.	Mean velocity.	Slope.	Coefficients.
No. 1	36.8	5.18	0.000114	80.0
No. 2	31.0	4.54	.000078	92.2
No. 3	30.5	3.99	.000060	93.6
No. 4	27.1	3.30	.000023	131.6

Considering the value of c to remain constant for any stage between 579 and 581, we may compute the fall required in each reach for the discharge corresponding to these stages. The fall from the lake to G. T. R. is so affected by wind and by rate of rise or fall of the lake surface that in the observations so far obtained the actual gauge relation is entirely masked by these effects. It would therefore appear that the effect of stage on slope above G. T. R. is comparatively small, and for present purposes it is considered that the change in fall for a given change in stage varies as the head required to produce the mean velocity at the smallest section of the reach, namely, at section "Arthur." The area of this section and the head required for the several values of Q are given below:

Huron stage.	579.	580.	581.
Q	175,920	194,950	213,980
Area section "Arthur"	34,250	35,000	35,750
$v=\frac{Q}{a}$	5.135	5.570	5.985
$h=\frac{v^2}{2g}$	.410	.482	.557

Change in h per foot change in stage=0.073 foot, whence h=fall above G. T. R., 0.770.

$$0.770+0.073=0.843. \qquad 0.770-0.073=0.697.$$

For the second reach we have—

Huron stage.	579.	580.	581.
Change in area = .9w	− 1,240	00	+ 1,240
Area	41,710	42,950	44,190
$v=\frac{Q}{a}$	4.218	4.539	4.842
P=	1,383	1,385	1,387
$r=\frac{a}{P}$	30.15	31.00	31.85
$h_2=l\frac{v^2}{c^2r}$	.222	.250	.277

Treating the third and fourth reaches in the same way, we find the following values for the fall:

Huron stage.	579.	580.	581.
h_3	0.222	0.250	0.277
h_4	.296	.330	.363

Kendall's gauge is about 1,400 feet above the mouth of Black River, and if the slope of the fourth reach is constant the fall between them is 0.029, 0.032, and 0.036 for lake stages 579, 580, and 581, respectively. Collecting, we have the following results:

Fall from Lake Huron level as represented by Sand Beach gauge.

For lake stage.	579.	580.	581.
To gauge G. T. R	0.697	0.770	0.843
To gauge waterworks	.919	1.020	1.120
To gauge Kendall	1.141	1.270	1.397
To gauge mouth Black River	1.170	1.302	1.433
To gauge dry dock	1.437	1.600	1.760

The straight inclined lines drawn on Plate XIII show the deduced fall for each gauge. The above results, derived from a study of the hydraulic conditions, give the relation $x=1.17+0.13\ y$ where x represents the fall from the lake and y is lake stage above 579 feet. As already stated, the only observations extending over several seasons by which we may check these conclusions are the records of water levels at the mouth of Black River since 1889, which gave this relation: $x=1.12+0.16\ y$. The two equations give the same result for lake stage, 580.7.

This relationship has been determined in the one case by considering that the discharge is proportional to lake stage, a supposition that would be expected to hold true under what we may call normal conditions. In the other case the relation is derived from actual observations extending over a term of years; and although these years show considerable variations, and we have comparatively few observations, yet we should expect that this method would also tend to eliminate the effect of abnormal conditions which may prevail in any one year.

It is not possible at present to trace in detail, year by year, the causes of these seemingly abnormal conditions of slope, but some of the possible causes may be briefly mentioned. If the lakes were fed by a constant supply, and if there were no evaporation and no obstructions to channels, the form of the outlets would govern the slopes, and equilibrium once established would not be disturbed. But during every winter a certain amount of water is stored in Lake Huron which, with an unobstructed channel, would find its way to Lake Erie. The evaporation from the lake surface may amount to as much as 6 inches in a month. How easily, then, may variations in winter storage and in the evaporation in summer disturb the equilibrium. And when it is recalled that an increase in discharge of 12,000 cubic foot-seconds, corresponding to an increase in fall at the head of the river of 0.1 foot, would result in an additional lowering of Lake Michigan-Huron of but 0.025 foot per month, it is clear that a disturbance of equilibrium is not quickly restored.

While it is realized that the foregoing discussion of the relation of stage, slope, and discharge is based upon assumptions which further investigation may show to be in error, it appears to give a reasonably accurate generalization of the question, which is all that the present data warrant. A detailed and accurate determination of this relation requires further observations of discharge at higher and lower lake stages, as well as under different conditions as to the relative elevations of Huron and Erie. Some further determinations of the discharge when the St. Clair River is obstructed by ice are also much needed, and a continuous record of the water level of the St. Clair River below the rapids, at some point between Black River and the discharge section, is seen to be a necessity.

From present data it is evident that we can hope to establish the general law of gauge relation only by a study of the conditions prevailing through a series of years, and we now propose to apply this method to the St. Clair River as a whole.

FALL FROM LAKE HURON TO LAKE ERIE.

In considering the total fall in the channel connecting Lakes Huron and Erie we are fortunate in having a series of water levels for the two lakes extending over a period of forty-five years without interruption. We have also a series at the St. Clair Flats Canal, 1873 to date, excepting the years 1879 to 1882; a series on the Detroit River at the light-house depot from 1867 to 1881; and a short series on Detroit River from 1861 to 1866, published in the report of Chief of Engineers for 1868. A series on the Detroit River made by the officials of the Detroit waterworks from 1853 to 1898, with the exception of 1860 to 1865, when only high and low stages were recorded, is also at our disposal through the courtesy of Mr. C. W. Hubbell, civil engineer to the board of water commissioners of the City of Detroit.

TABLE No. 20.—*Summary of water levels, St. Clair and Detroit Rivers, six month means—June to November, inclusive.*

Year.	Elevation of water surface in feet above mean tide at New York (levels of 1877).						Fall in feet.		
	Lake Huron.	Lake St. Clair.	Light-house depot, Detroit River.	Water-works, Orleans street.	Water-works, above Belle Isle.	Lake Erie at Cleveland.	Lake Huron to Lake St. Clair.	Lake St. Clair to Lake Erie.	Lake Huron to Lake Erie.
1855	581.69	*576.43*	*575.99*	575.88	....	573.65	*5.26*	*2.78*	8.04
1856	581.49	*575.99*	*575.55*	575.44	....	573.00	*5.50*	*2.99*	8.49
1857	582.62	*576.82*	*576.38*	576.27	....	573.83	*5.80*	*2.99*	8.79
1858	583.05	*577.52*	*577.08*	576.97	....	574.82	*5.53*	*2.70*	8.23
1859	583.07	*577.02*	*576.58*	576.47	....	574.37	*6.05*	*2.65*	8.70
1860	582.45	....	....	....	....	573.66	....	....	8.79
1861	582.83	*576.88*	576.44	....	....	574.05	*5.95*	*2.83*	8.78
1862	582.49	*576.92*	576.48	....	....	573.89	*5.57*	*3.03*	8.60
1863	581.94	*576.45*	576.01	....	....	573.38	*5.49*	*3.07*	8.56
1864	581.40	*576.25*	575.81	....	....	573.05	*5.15*	*3.20*	8.35
1865	581.30	*576.09*	575.65	....	....	572.85	*5.21*	*3.24*	8.45
1866	580.98	*576.06*	575.62	575.53	....	573.01	*4.92*	*3.05*	7.97
1867	581.35	*576.17*	575.73	575.61	....	572.90	*5.18*	*3.27*	8.45
1868	580.72	*575.66*	575.22	575.24	....	572.71	*5.06*	*2.95*	8.01
1869	581.24	*575.92*	575.48	575.53	....	573.20	*5.32*	*2.72*	8.04
1870	581.96	*576.41*	575.97	576.15	....	573.51	*5.55*	*2.90*	8.45
1871	581.79	*576.10*	575.66	575.78	....	572.94	*5.69*	*3.16*	8.85
1872	580.92	*575.50*	575.06	574.76	....	572.10	*5.42*	*3.40*	8.82
1873	581.50	575.98	575.58	575.20	....	572.97	5.52	3.01	8.53
1874	581.52	576.02	575.57	575.26	....	573.02	5.50	3.00	8.50
1875	581.56	575.87	575.41	575.13	....	572.77	5.69	3.10	8.79
1876	582.82	577.12	576.62	576.50	....	574.07	5.70	3.05	8.75
1877	581.97	576.25	575.82	575.70	....	573.13	5.72	3.12	8.84
1878	581.84	576.37	575.95	....	575.90	573.48	5.47	2.89	8.36
1879	580.85	*575.56*	575.12	....	575.14	572.65	*5.29*	*2.91*	8.20
1880	581.36	*575.96*	575.52	....	575.47	572.99	*5.40*	*2.97*	8.37
1881	581.60	*575.94*	575.50	....	575.71	572.99	*5.66*	*2.95*	8.61
1882	581.95	*576.54*	*576.10*	....	576.19	573.73	*5.41*	*2.81*	8.22
1883	582.49	577.09	....	....	576.44	573.85	5.40	3.24	8.64
1884	582.34	576.80	....	....	576.10	573.54	5.54	3.26	8.80
1885	582.66	576.85	....	....	576.34	573.92	5.81	2.93	8.74
1886	582.72	576.72	....	....	576.20	573.60	6.00	3.12	9.12
1887	581.98	576.36	....	....	575.83	573.40	5.62	2.96	8.58
1888	581.56	575.92	....	....	575.45	572.92	5.64	3.00	8.64
1889	580.95	575.59	....	....	575.27	572.62	5.36	2.97	8.33
1890	580.93	575.86	....	....	575.60	573.31	5.07	2.55	7.62
1891	580.09	575.00	....	....	574.66	572.12	5.09	2.88	7.97
1892	580.24	575.40	....	....	575.05	572.82	4.84	2.58	7.42
1893	580.54	575.41	....	....	575.01	572.49	5.13	2.92	8.05
1894	580.55	575.33	....	....	574.89	572.34	5.22	2.99	8.21
1895	579.44	574.35	....	....	573.90	571.29	5.09	3.06	8.15
1896	579.37	574.62	....	....	574.15	571.76	4.75	2.86	7.61
1897	580.10	575.05	....	....	574.68	572.29	5.05	2.76	7.81
1898	580.08	575.15	....	....	574.68	572.31	4.93	2.84	7.77
1899	580.27	575.10	....	....	....	572.26△	5.17	2.84	8.01

REMARKS.

NOTE.—Readings not directly observed are italics.

Authorities.—Lake Huron, 1855–1859, Lake Michigan levels. Report of United States Deep Waterway Commission, 1896, p. 176. 1860–1864, Point Aux Barques, Mich; 1865–1870, Milwaukee, Wis.; 1871–1874, Port Austin, Mich.; 1875–1899, Sand Beach, Mich. Reports of Chief of Engineers, U. S. A.

Lake St. Clair: 1855–1872, 1879–1882, derived from levels of light-house depot by adding 0.44 foot, which is the mean fall from 1873–1878. 1882, partial records at flats indicate a higher level than that given above. 1873-1878, 1883-1899, readings at St. Clair Flats Canal. Corps of Engineers, U. S. A.

Light-House Depot: 1855–1859, derived from levels at waterworks, Orleans street, by adding 0.11 foot, which is the mean fall from 1867–1877. 1861–1866, Report of United States Lake Survey, 1868. Monthly mean of readings were subtracted from 577.77. 1867–1881, Report of Chief of Engineers, U. S. A. 1882, derived from waterworks by subtracting .09 foot. (Light-house depot is below Belle Isle.)

Waterworks, Orleans street: From readings by Detroit waterworks officials.

Waterworks, above Belle Island: From readings by Detroit waterworks officials.

Waterworks gauge.—Note: Zero originally 580.30. In 1894 this zero was found to be at 580.78. In the above reduction to mean tide this change in elevation of zero is considered to have taken place between 1888 and 1889.

Lake Erie: 1855–1898, Cleveland. Reports of Chief of Engineers, U. S. A. △ 1899, Amherstburg, Ontario. Corps of Engineers, U. S. A.

In presenting a summary of these water levels in Table No. 20, only the months that are entirely free from ice have been considered, and the result for each year is the mean of the levels for the six months June to November, inclusive. In order to obtain a continuous record of the fall in St. Clair River alone, the level of Lake St.

Clair for the several years when no record was kept at the St. Clair Flats has been deduced from the Detroit River readings by adding 0.44 foot, which is the mean fall from the flats to light-house depot for six years when records were kept at both places. The results for Lakes Huron, St. Clair, and Erie are shown on Pl. XVI. (It may be well to again call attention to the fact that the fall from the flats to Detroit is in reality 0.378 foot greater than shown by this table, the precise level line of 1899 having shown that discrepancy in the levels carried to New Baltimore from Port Huron at the head of St. Clair River, and from Gibraltar at the foot of Detroit River; but as this discrepancy occurs between Windmill Point and New Baltimore it affects only the fall in Lake St. Clair.)

The table shows clearly that since 1888 the fall in St. Clair River has been less than in former years, and the mean results for several groups of years are shown in the following table:

Number of years.	Period.	Mean elevation Lake Huron.	Mean elevation Lake St. Clair.	Mean fall.
17	1855–1872	581.81	576.36	5.45
16	1873–1888	581.92	576.33	5.59
11	1889–1899	580.23	575.17	5.06

This change in fall in the St. Clair River has been attributed to a supposed change in regimen through the gorge at the head of the river, and since this opinion has been given some publicity it may be well to consider the question in some detail. In December, 1898, a cursory survey of the narrowest section of the river was made in accordance with your orders, and in 1899 the conditions at the head of the river were carefully developed. The results of this survey are shown on Plate I. The individual soundings are not shown on this plate, but the area was thoroughly covered, and the conditions are better represented by the submarine contours 10 feet apart. The successive cross sections of the river will also assist in bringing out the form of the channel. The 60-foot submarine contour extends from a point opposite the light-house to a little below section "Arthur," some 3,200 feet. Within the northern half of this area there is a very narrow 70-foot area about 1,400 feet long. To the westward of this area there is a shoal with a minimum depth of about 22 feet. Between this and the American shore there is a narrow channel having 36 feet of water, the 30-foot curve running up above the light-house about 400 feet. Between sections "Culvert" and "Fish" the shoal runs out, and the two channels merge in one. These characteristics are clearly brought out by the contours and cross sections.

Two surveys had previously been made of this locality, one in 1859 and one in 1867. The soundings shown on the map of the 1859 survey are apparently accurately located, and in general they agree very closely indeed with the results of our recent survey. The only changes apparent since 1859 are as follows: The 70-foot area appears to have been extended about 700 feet downstream, with a width of only 50 feet. It may also have shifted to the westward a little, and the deep channel near the west shore may have diminished in width. If these changes are real the area of cross section at the immediate head of the river remains about the same, all lines having been shifted a little to the westward. In the vicinity of section "Arthur" but few soundings are given on the 1859 map, but it appears that the 50-foot and the 60-foot contours may have been extended downstream about 600 feet each, the 60-foot contour having terminated in 1859 about 400 feet above section "Arthur." The width of this section has apparently been reduced about 50 feet since 1859 by the building of docks. Below section "Stauber" the soundings plotted are so infrequent that no definite conclusions can be drawn, though it appears that the deep-water areas have moved to the west, toward the concave bank, and a possible deepening of 5 feet may have taken place over small areas.

The survey of 1867 is by no means as satisfactory, although a large number of soundings are available. The method followed seems to have been to sound on lines between shore stations without locating any of the soundings. This renders the actual location quite indeterminate. To distribute the soundings along the lines equidistant does not make the lines consistent with one another, and is indeed a very improbable distribution, considering the existing currents. A reasonable distribution can be made which will agree almost perfectly with present conditions, and any distribution which can be made establishes the fact that the 60-foot curve has not been extended since that time. In the central channel east of the light-house two 66-foot soundings were obtained in 1867 which agree with the present

depth; to the westward appears the shoal, and the deep channel with 36 feet of water nearer the shore. There are four soundings of 60 feet at about section "Fish," one above section "Arthur," and one just below this section, which is the present limit of the 60-foot curve. No 70-foot soundings were obtained in 1867, but since the 70-foot area existed in 1859, as at present, and since only one line of soundings crossed this area in 1867 at a point where it exceeds 50 feet in width, it is not strange that it was missed.

Although the data furnished by the previous surveys are imperfect we may conclude that between 1859 and 1867 the area of cross section of the river at the most restricted point may have increased in area about 9,000 square feet for a length of about 600 feet, the 50-foot and 60-foot contours having been extended downstream about this distance. It also appears that since 1859 the deepest channel may have moved a little to the westward or toward the concave bank. There is no evidence of any important changes in area above section "Arthur" since 1867, and it is quite certain that the limits of the 60-foot depth have not been extended downstream since that time. Below this section the depths may have increased a few feet over narrow areas.

As to the effect of the extension of the 60-foot curve between 1859 and 1867, if the restricted cross section acts as a submerged weir its effect would be quite important, but if it is considered simply as a portion of the stream the effect on the slope would be very small. The mean fall in the St. Clair River from 1861 to 1867 was about three-tenths of a foot less than the fall from 1855 to 1859, but the level of Lake Huron had also fallen, and when the Huron level was restored in 1876 and 1886 the high slope was again found.

Since the mean annual fluctuation of the water surface of Lake Erie is greater than that of Lake Michigan-Huron, the conclusion has been drawn that in high stages the slope in the connecting channel is low and that in low stages the slope is high. While, as will be shown, this is partially true as regards the seasonal changes in stage, and can easily be explained, it is an entirely erroneous conclusion as applied to years of high and low water. On the contrary, when we consider a term of years, it is found that the relation of stage to slope is well marked, though subject to occasional variations, as in the case of the fall at the head of the river.

The relation of the fall in the St. Clair River to the level of Lake Huron is brought out on Plate XIV, fig. 1, in which the elevation of Lake St. Clair is plotted with reference to the stage of Lake Huron, the six-month mean values for June to November being used. (Table No. 20.)

Since the question under consideration is whether a permanent change in the slope of the river occurred about 1888, due to changes in regimen at the rapids, we will consider the relation of slope to stage for the two periods before and after the supposed change. We have therefore computed by the method of least squares the relation of the level of Lake St. Clair to that of Lake Huron for thirty-three years, 1855 to 1888, excepting 1860, when no levels are available. The equation expressing this relation is found to be—

$$\text{Lake St. Clair} = 574.32 + 0.707\ (\text{Huron stage} - 579) \quad . \quad . \quad . \quad (\text{eq. } 1)$$

expressed as relation of fall to Huron stage this becomes

$$\text{Fall in St. Clair River} = 4.68 + 0.293\ (\text{Huron stage} - 579) \quad . \quad (\text{eq. } 2)$$

That is, a rise in Lake Huron of 1 foot occasions an increase in fall of about 0.29 foot. While this relation is by no means fulfilled at all times it represents, as nearly as the data will allow, the normal condition existing from 1855 to 1888. Treating the eleven years, 1889 to 1899, since this change in regimen is said to have taken place, in the same manner, we find the equation—

$$\text{Lake St. Clair} = 574.20 + .788\ (\text{Huron} - 579) \text{ or} \quad . \quad . \quad . \quad . \quad (\text{eq. } 3)$$
$$\text{Fall in St. Clair River} = 4.80 + .312\ (\text{Huron} - 579) \quad . \quad . \quad . \quad (\text{eq. } 4)$$

The difference between the equations (2 and 4) is in the wrong direction to indicate an enlargement of section, but this is of no consequence, for it is too small to indicate any change in area; it is due simply to the fact that Lake Huron is not the only factor controlling this fall, and it is only by taking a long series of years that we may arrive at the normal relationship.

Having established as far as possible by this method that there has been no change in hydraulic conditions in recent years, we may now determine the equation which most nearly expresses the relation of fall to stage for forty-four years' observations, and this is found to be:

$$\text{Fall} = 4.67 + .30\ (\text{Huron} - 579).$$

On Plate XIV, fig. 1, the straight line represents the relation of the elevation of Lake St. Clair to Lake Huron as deduced from this equation. In Table No. 21 the elevation of Lake St. Clair is computed by this equation for each year, and the results are given in column *f*, the computed fall is given in column *g*, and the error of the computed value for each year appears in column *h*. It is seen that the computed values are in error as much as 0.30 foot in three years, but for thirty-three years the error is less than 0.20 foot.

TABLE No. 21.—*Fall in St. Clair River in terms of Huron and Erie stage.*

Year.	Observed six months means.—Water surface from table.			Computed by Equation 5.				Computed by Equation 7.		
	Lake Huron.	Lake St. Clair.	Lake Erie.	Fall Huron to St. Clair.	St. Clair.	Fall Huron to St. Clair.	Residual.	St. Clair.	Fall Huron to St. Clair.	Residual.
a	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*j*	*k*
1855	581.69	*576.43*	573.65	*5.26*	576.21	5.48	+.22	576.39	5.30	+.04
1856	581.49	*575.99*	573.00	*5.50*	576.07	5.42	−.18	576.02	5.47	−.03
1857	582.62	*576.82*	573.83	*5.80*	576.86	5.76	−.04	576.85	5.77	−.03
1858	583.05	*577.52*	574.82	*5.53*	577.17	5.88	+.35	577.48	5.57	+.04
1859	583.07	*577.02*	574.37	*6.05*	577.18	5.89	−.16	577.29	5.78	−.27
1860	......	......	......	......	......	......	......	......	......	......
1861	582.83	*576.88*	574.05	*5.95*	577.01	5.82	−.13	577.04	5.79	−.16
1862	582.49	*576.92*	573.89	*5.57*	576.77	5.72	+.15	576.83	5.66	+.09
1863	581.94	*576.45*	573.38	*5.49*	576.39	5.55	+.06	576.38	5.56	+.07
1864	581.40	*576.25*	573.05	*5.15*	576.01	5.39	+.24	576.01	5.39	+.24
1865	581.30	*576.09*	572.85	*5.21*	575.94	5.36	+.15	575.88	5.42	+.21
1866	580.98	*576.06*	573.01	*4.92*	575.72	5.26	+.34	575.82	5.16	+.24
1867	581.35	*576.17*	572.90	*5.18*	575,98	5.37	+.19	575.92	5.43	+.25
1868	580.72	*575.66*	572.71	*5.06*	575.53	5.19	+.13	575.58	5.14	+.08
1869	581.24	*575.92*	573.20	*5.32*	575.90	5.34	+.02	576.01	5.23	−.09
1870	581.96	*576.41*	573.51	*5.55*	576.40	5.56	+.01	576.44	5.52	−.03
1871	581.79	*576.10*	572.94	*5.69*	576.28	5.51	−.18	576.12	5.67	−.02
1872	580.92	*575.50*	572.10	*5.42*	575.67	5.25	−.17	575.38	5.54	+.12
1873	581.50	575.98	572.97	5.52	576.08	5.42	−.10	576.01	5.49	−.03
1874	581.52	576.02	573.02	5.50	576.09	5.43	−.07	576.05	5.47	−.03
1875	581.56	575.87	572.77	5.69	576.12	5.44	−.25	575.94	5.62	−.07
1876	582.82	577.12	574.07	5.70	577.00	5.82	+.12	577.04	5.78	+.08
1877	581.97	576.25	573.13	5.72	576.41	5.56	−.16	576.28	5.69	−.03
1878	581.84	576.37	573.48	5.47	576.32	5.52	+.05	576.38	5.46	−.01
1879	580.85	*575.56*	572.65	*5.29*	575.62	5.23	−.06	575.60	5.25	−.04
1880	581.36	*575.96*	572.99	*5.40*	575.98	5.38	−.02	575.96	5.40	00
1881	581.60	*575.94*	572.99	*5.66*	576.15	5.45	−.21	576.06	5.54	−.12
1882	581.95	*576.54*	573.73	*5.41*	576.40	5.55	+.14	576.54	5.41	00
1883	582.49	577.09	573.85	5.40	576.77	5.72	+.32	576.81	5.68	+.28
1884	582.34	576.80	573.54	5.54	576.67	5.67	+.13	576.61	5.73	+.19
1885	582.66	576.85	573.92	5.81	576.89	5.77	−.04	576.91	5.75	−.06
1886	582.72	576.72	573.60	6.00	576.93	5.79	−.21	576.79	5.93	−.07
1887	581.98	576.36	573.40	5.62	576.42	5.56	−.06	576.40	5.58	−.04
1888	581.56	575.92	572.92	5.64	576.12	5.44	−.20	576.01	5.55	−.09
1889	580.95	575.59	572.62	5.36	575.70	5.25	−.11	575.63	5.32	−.04
1890	580.93	575.86	573.31	5.07	575.68	5.25	+.18	575.94	4.99	−.08
1891	580.09	575.00	572.12	5.09	575.09	5.00	−.09	575.05	5.04	−.05
1892	580.24	575.40	572.82	4.84	575.20	5.04	+.20	575.43	4.81	−.03
1893	580.54	575.41	572.49	5.13	575.41	5.13	00	575.41	5.13	00
1894	580.55	575.33	572.34	5.22	575.42	5.13	−.09	575.34	5.21	−.01
1895	579.44	574.35	571.29	5.09	574.64	4.80	−.29	574.42	5.02	−.07
1896	579.37	574.62	571.76	4.75	574.59	4.78	+.03	574.60	4.77	+.02
1897	580.10	575.05	572.29	5.05	575.10	5.00	−.05	575.14	4.96	−.09
1898	580.08	575.15	572.31	4.93	575.09	4.99	+.06	575.14	4.94	+.01
1899	580.27	575.10	572.26	5.17	575.22	5.05	−.12	575.19	5.08	−.09

NOTE.—For details concerning water levels see Table No. 20. Equation 5: Fall Huron to St. Clair = 4.67 feet +.30 (Huron − 579). Equation 7: Fall Huron to St. Clair = 4.67 feet +.593 (Huron − 579) −.452 (Erie − 571.50).

The effect of Lake Erie on the elevation of Lake St. Clair has not thus far been considered, as in the preceding equations the fall in the St. Clair River is made to depend upon the elevation of Lake Huron alone, while Lakes Huron and Erie generally rise and fall somewhat in unison on account of the similar climatic conditions and the partial control of Erie by Huron; yet they do not always act together. From 1865 to 1866 Huron fell 0.3 foot, while Erie rose 0.15 foot, and from 1866 to 1867 the reverse occurred. At such times Lake Erie must have an independent effect on the level of Lake St. Clair, and from the results of forty-four years' observations we may

obtain the equation expressing the elevation of Lake St. Clair in terms of the elevation of Huron and Erie as follows:

$$C=576.05+.407\ (H-581.46)+.452\ (E-573.09). \quad . \quad . \quad . \quad . \qquad (6)$$

where C is the elevation of Lake St. Clair above mean tide and H and E are the elevations of Lakes Huron and Erie, respectively. By a simple transformation we find the fall in St. Clair River

$$f=4.67+.593\ (H-579.0)-.452\ (E-571.50). \quad . \quad . \quad . \quad . \quad . \qquad (7)$$

In Table No. 21, column k, the difference between the observed fall and that computed by equation (7) is given for each year, and it is seen that these residuals are in general very small. The greatest error of the computed fall is 0.28 foot in 1883. There are ten years in which the error exceeds 0.1 foot and but five years when it exceeds 0.2 foot. This equation then expresses very closely the relation which has existed between the level of Lake St. Clair and that of Lakes Huron and Erie for forty-four years, and indicates that the level of Lake St. Clair is so nearly controlled by the lakes above and below it that its local supply can have little effect on the variations in its annual mean level, though it may affect its monthly mean, as will appear later.

On Plate XVI the computed and observed elevations of Lake St. Clair are shown by the two curves, and the correspondence is thus brought out graphically. The full line represents observed elevations and the dash line shows the computed values. Had a pronounced change in regimen taken place at the head of the river between 1886 and 1888, such as an important scour at the rapids, the same equation would not express this relationship before and after the change, because the fall in the St. Clair River would have been less for a given discharge after the scour; yet it is seen that the computed and actual elevations of Lake St. Clair are in very close agreement from 1868 to 1882 and from 1885 to 1899.

Neither is the present low fall in the river unprecedented, for in 1866 it was lower than in the past three years, and during the five years 1864 to 1868 the mean fall in the St. Clair River was but 0.1 foot greater than in the past five years, although the stage was about a foot higher. During 1847 and 1848 the level of Huron was as low as at present. According to the published record the mean fall from Huron to Erie for the four months of May and October, 1847 and 1848 (the only months for which we have the Erie record in these two years), is less than 7 feet, and the result at the waterworks in Detroit for the only one of these months when we have a record is consistent with the record for Erie.

We have thus shown, first, that the surveys furnish no evidence of a change in the regimen of the St. Clair River since 1867, though they indicate that a small permanent change may have taken place between 1859 and 1867; second, that the water levels indicate that no permanent change of importance has taken place in the conditions governing the slope in the St. Clair River; and third, that the present relative elevations of the lakes is not unprecedented, and hence that there is no reason to suppose that, as far as natural conditions are concerned, the level of Lake Huron will not return to its normal stage.

The fact still remains, however, that the mean level of Lake Huron for the past ten years is about 1.70 feet below the mean for the preceding thirty-four years, while Lake Erie is but 1 foot below that mean. As to the reason for this condition, it is possible that the improvement of the channel of the Detroit River may have had a slight effect, certainly not exceeding 0.2 foot. Considering the lower lake system as a whole, there is little question that the deficiency in precipitation in the recent years is sufficient to account for the present levels, and without going into this question of precipitation and evaporation, it may be said that it is quite possible the deficiency of the former and the excess of the latter for Lake Michigan-Huron as compared to Lake Erie might be sufficient to account for the lower level of Lake Huron. But since the climatic conditions on the two lakes are usually similar, to attribute this difference in level to a change in this respect will not carry much weight unless established by an analysis of the existing data.

There is a possible explanation of the question, however, which does not involve any changes in channel depth or differences in climatic conditions between the two lakes. It makes the present low water of Lake Huron depend upon natural causes which may be removed, and if at this time the precipitation return to the normal the lakes will return to their usual stage.

The effect of changes in slope at the head of St. Clair River upon the discharge from Lake Huron has been mentioned above, and it has been shown that a decrease in fall of 0.01 foot in 4.4 miles between G. T. R. and dry dock may occasion a decrease in discharge of approximately 1,200 cubic-foot seconds, this value having been determined by two measurements of discharge in December, 1898, when the water was

backed up by ice, one of these measurements having shown a discharge of 47,600 cubic-foot seconds below the normal when the fall was 0.39 foot below that corresponding to the stage.

During the past winter the water levels taken at Sand Beach and mouth of Black River gave the following results:

Month.	Sand Beach.	Black River.	Fall.	Normal fall without ice effect.	Difference.
January	579.38	578.52	0.86	1.20	0.34
February	579.38	578.79	0.59	1.20	.61
March	579.42	578.76	0.66	1.20	.54

Assuming a decrease in discharge of 1,200 cubic-foot seconds for each 0.01 foot decrease in the fall at the head of the river, we derive the effect of ice on the discharge as given in the table below, and since a change in discharge of 10,000 cubic-foot seconds is equivalent to a depth of about 0.02 foot a month over Lake Michigan-Huron, we have the resulting storage as shown, which for the three months amounts to 0.36 foot.

Month.	Fall diminished by ice.	Corresponding decrease in discharge.	Storage depth.
	Feet.	*Cubic-foot seconds.*	*Feet.*
January, 1900	0.34	40,800	0.082
February, 1900	0.61	73,200	.146
March, 1900	0.56	64,800	.130
Total, three months			.36

That is, if we accept this reasoning, the level of Lake Michigan-Huron is, in the spring of 1900, 0.36 foot higher than it would have been if we had had no ice in the St. Clair River during the past winter.

During the fourteen years from 1875 to 1888 there was a mean of twelve days each winter when the temperature, as recorded by the Weather Bureau at Port Huron, went below 14° F. in December and January, while from 1889 to 1899 the mean number of days in these months when the temperature went below 14° was six. During the past winter there were eight days in December and January when the temperature went below 14°. The formation of ice depends upon the occurrence of very low temperature lasting for several days, so that it may be estimated by the number of very cold days better than by the mean temperature. Judged by this standard then, it is reasonable to suppose that the ice effect has been much less during the past ten years than it had been during the preceding fourteen years.

Let us consider how the formation of ice in the lower St. Clair River would affect the water levels in any given year. The discharge being greatly diminished, Lake St. Clair would tend to drain off into Lake Erie during the winter, and it would be lowered to such a point that the flow through the Detroit River would approximately equal the discharge through the St. Clair. The elevation of this point would depend upon the relative effects of ice on the two rivers, but the effect on the St. Clair is usually much greater than on the Detroit. The total fall in the St. Clair would thus be increased, while that in the Detroit would be diminished. The difference between the diminished supply to Lake Erie and the diminished outflow following the lower level would be shown by the greater total fall between Huron and Erie during the months of ice effect than would naturally exist without ice.

In 1873 water-gauge readings were started at St. Clair Flats Canal, and have been continued since that time, except that from 1879 to 1883 readings were omitted during part of each year. We have therefore taken out in one group the means of the months for lakes Huron, St. Clair, and Erie from 1873 to 1887, omitting 1879 to 1883, inclusive, and in another group from 1888 to 1899, inclusive. The resulting mean monthly falls are given in Table No. 22, and those are shown graphically on Plate XVII.

TABLE No. 22.—*Water levels of lakes Huron, St. Clair, and Erie, comparing means of the months for two groups of years.*

10 YEARS, 1873-1878 AND 1884-1887.

Month.	Elevation of water surface.			Fall in feet.		
	Lake Huron.	Lake St. Clair.	Lake Erie.	Lake Huron to Lake St. Clair.	Lake St. Clair to Lake Erie.	Lake Huron to Lake Erie.
January	581.458	575.627	572.583	5.831	3.044	8.875
February	581.447	575.273	572.601	6.174	2.672	8.846
March	581.536	575.792	572.744	5.744	3.048	8.792
April	581.675	576.157	573.296	5.518	2.861	8.379
May	581.997	576.328	573.650	5.669	2.678	8.347
June	582.220	576.654	573.798	5.566	2.856	8.422
July	582.347	576.758	573.774	5.589	2.984	8.573
August	582.275	576.658	573.616	5.617	3.042	8.659
September	582.079	576.399	573.372	5.680	3.027	8.707
October	581.935	576.180	572.996	5.755	3.184	8.939
November	581.695	575.955	572.783	5.740	3.172	8.912
December	581.516	576.014	572.785	5.502	3.229	8.731

12 YEARS, 1888-1899.

Month.	Lake Huron.	Lake St. Clair.	Lake Erie.	Lake Huron to Lake St. Clair.	Lake St. Clair to Lake Erie.	Lake Huron to Lake Erie.
January	579.664	574.770	571.773	4.894	2.997	7.891
February	579.608	574.476	571.725	5.132	2.751	7.883
March	579.677	574.555	571.851	5.122	2.704	7.826
April	579.873	574.868	572.316	5.005	2.552	7.557
May	580.213	575.161	572.633	5.052	2.528	7.580
June	580.532	575.458	572.872	5.074	2.586	7.660
July	580.638	575.567	572.808	5.071	2.759	7.830
August	580.581	575.462	572.593	5.119	2.869	7.988
September	580.369	575.243	572.296	5.126	2.947	8.073
October	580.081	574.942	571.948	5.139	2.994	8.133
November	579.860	574.719	571.740	5.141	2.979	8.120
December	579.651	574.709	571.677	4.942	3.032	7.974

Comparing the results of the first ten years with the curves of the past twelve years, the greater effect of ice during the former period seems to be clearly shown. In the first place it is noticed that the mean annual range of Lake Huron has been increased from 0.9 foot, as in former years, to 1.03 feet, the winter months now showing a relatively lower stage. The St. Clair curve is very instructive. It shows that in the earlier period the water surface of Lake St. Clair fell rapidly in January and February, when it was drained off into Lake Erie, while in later years the subsidence of level is but half as great. But these points are most strikingly shown by the mean annual curves of fall in the St. Clair River. The range in the mean annual curve of fall for recent years is but 3 inches, whereas the range in the mean curve in the earlier period was 8 inches. A reference to the Plate XVII will show the disturbance in this slope between December and April, and the very much smaller disturbance in the past twelve years. The range in the fall of the Detroit River has not been changed, though in recent years the curve is smoother. The maximum fall is shown in December as before, but the minimum, which occurred in February, is eliminated, and only one minimum, that of May, is shown in the mean curve of recent years.

A word may be added here as to the cause of the condition already mentioned, that in the channel connecting lakes Huron and Erie the fall is greater in those months when the water level is receding. This is occasioned by the facts, first, that Lake Erie has a greater mean annual range in level than has Michigan-Huron, due in part at least to the effect of the supply to the former from the latter; and second, that the seasons are earlier on Erie than on Michigan-Huron. Comparing the mean annual curves of Huron and Erie it is seen that Erie reaches its maximum in June, and begins to fall while Huron is still rising. The Huron curve from July to October is almost identical with the Erie curve from June to September; that is, there is practically the same subsidence in the two lakes during the three months succeeding the maximum, but since Erie is about a month in advance, the fall in the connecting channel is increasing with a falling stage. As Erie reaches its maximum a month earlier than Huron, so is its subsidence checked a month earlier, and we have from November to April a generally decreasing fall in the connecting channel. Between March and April Huron rises slowly, but Erie, on account of its earlier season, has a sharp rise in this month, causing the occurrence of the lowest fall of the year either in April or May. Thus we have a cyle of changes resulting in a low slope in the first half of the year and a high slope in the latter half, due to seasonal

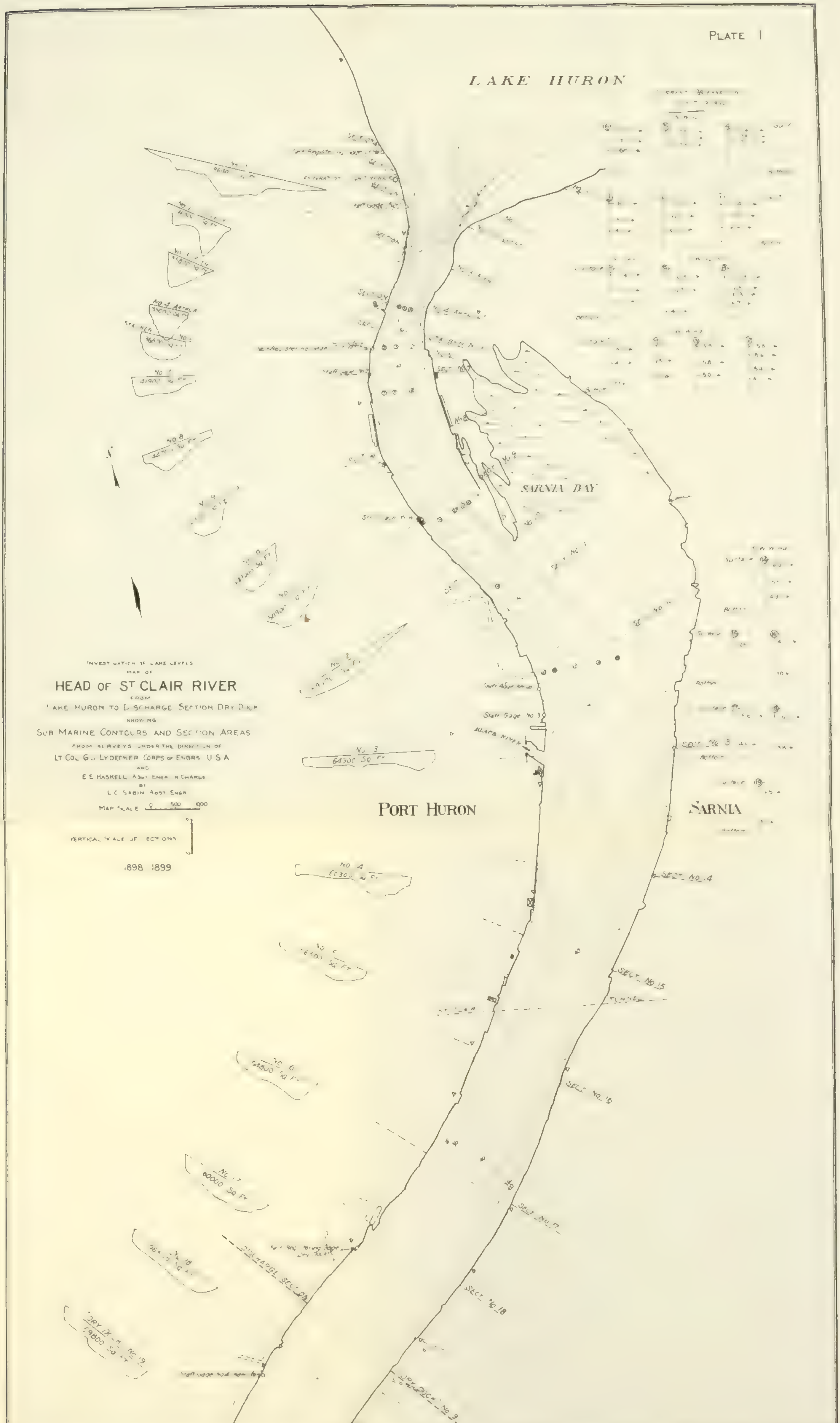


PLATE 1
LAKE HURON
SARNIA BAY
HEAD OF ST CLAIR RIVER
SUB MARINE CONTOURS AND SECTION AREAS
LT COL G. J. LYDECKER CORPS OF ENGRS U.S.A.
E.E. HASKELL ASST ENGR IN CHARGE
L.C. SABIN ASST ENGR
MAP SCALE 0 500 1000
1898 1899
No. 3
64300 SQ FT
Staff Gage No 3
BLACK RIVER
PORT HURON
SARNIA
SECT. No. 4
SECT. No. 15
SECT. No. 16
SECT. No. 17
DISCHARGE SECTION
SECT. No. 18
DRY DOCK No. 19
69800 SQ FT

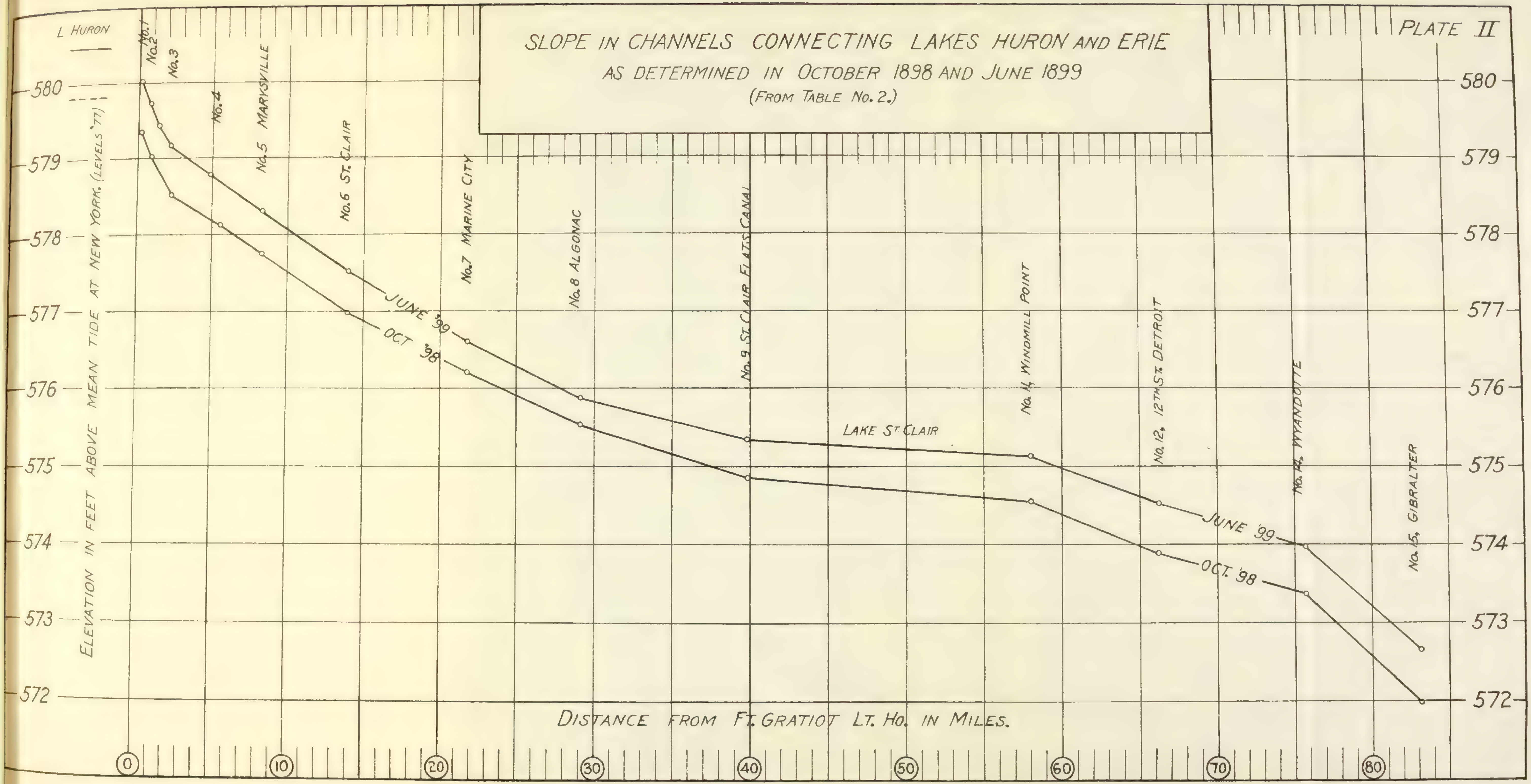
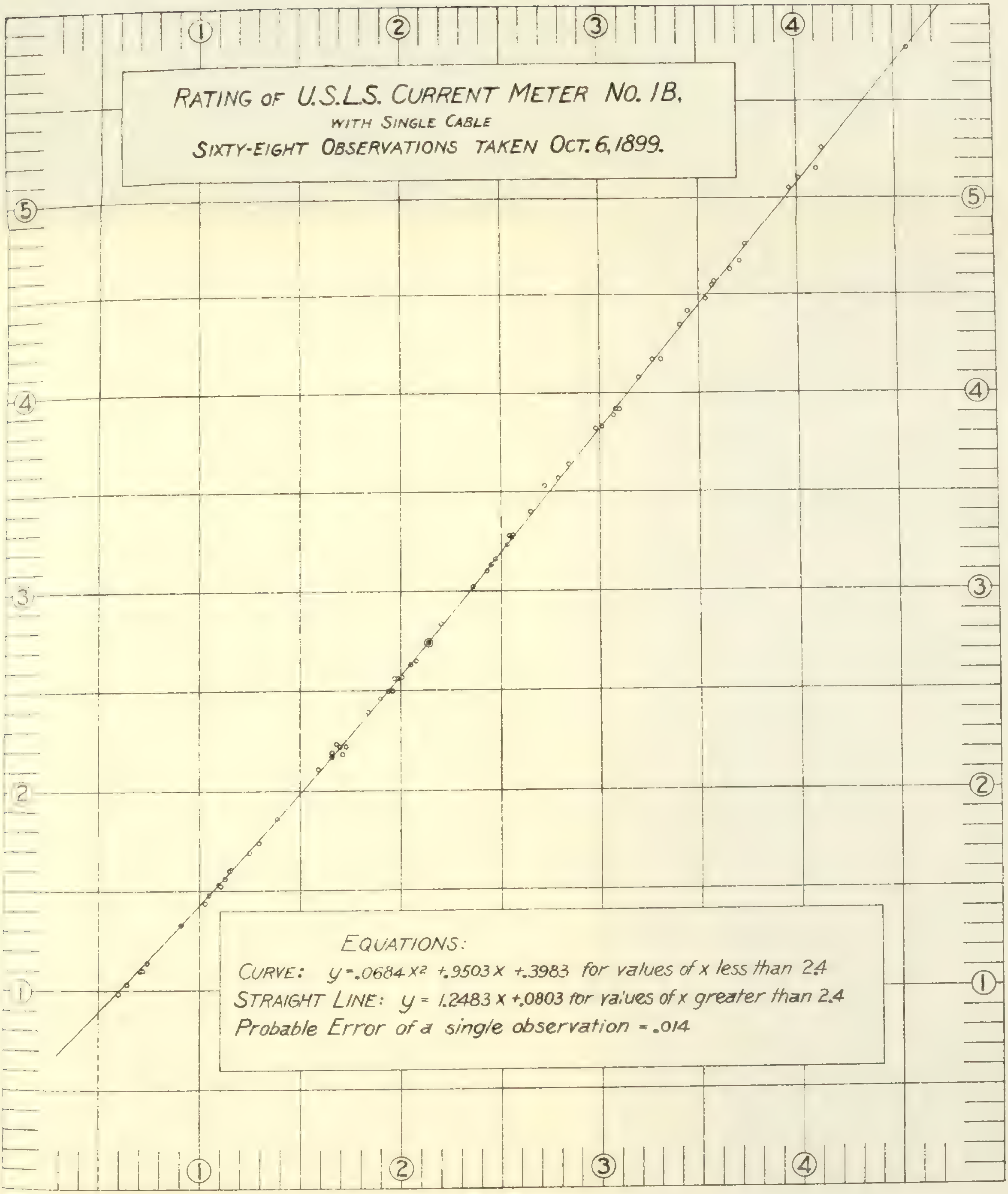


PLATE II
SLOPE IN CHANNELS CONNECTING LAKES HURON AND ERIE
AS DETERMINED IN OCTOBER 1898 AND JUNE 1899
(FROM TABLE No. 2.)
L HURON
No. 1
No. 2
No. 3
No. 4
No. 5 MARYSVILLE
No. 6 ST. CLAIR
No. 7 MARINE CITY
No. 8 ALGONAC
No. 9 ST. CLAIR FLATS CANAL
LAKE ST. CLAIR
No. 11, WINDMILL POINT
No. 12, 12TH ST. DETROIT
No. 14, WYANDOTTE
No. 15, GIBRALTER
JUNE '99
OCT. '98
ELEVATION IN FEET ABOVE MEAN TIDE AT NEW YORK. (LEVELS '77)
580
579
578
577
576
575
574
573
572
DISTANCE FROM FT. GRATIOT LT. HO. IN MILES.
0
10
20
30
40
50
60
70
80

Eng 56 2

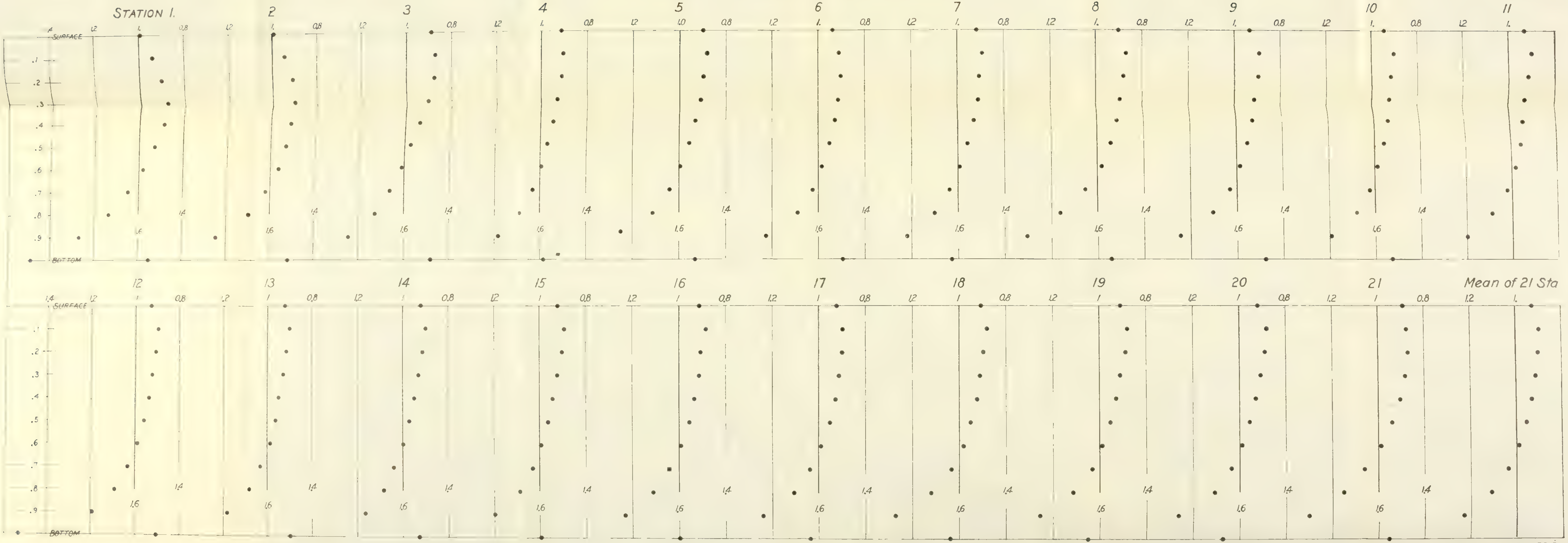
Plate III



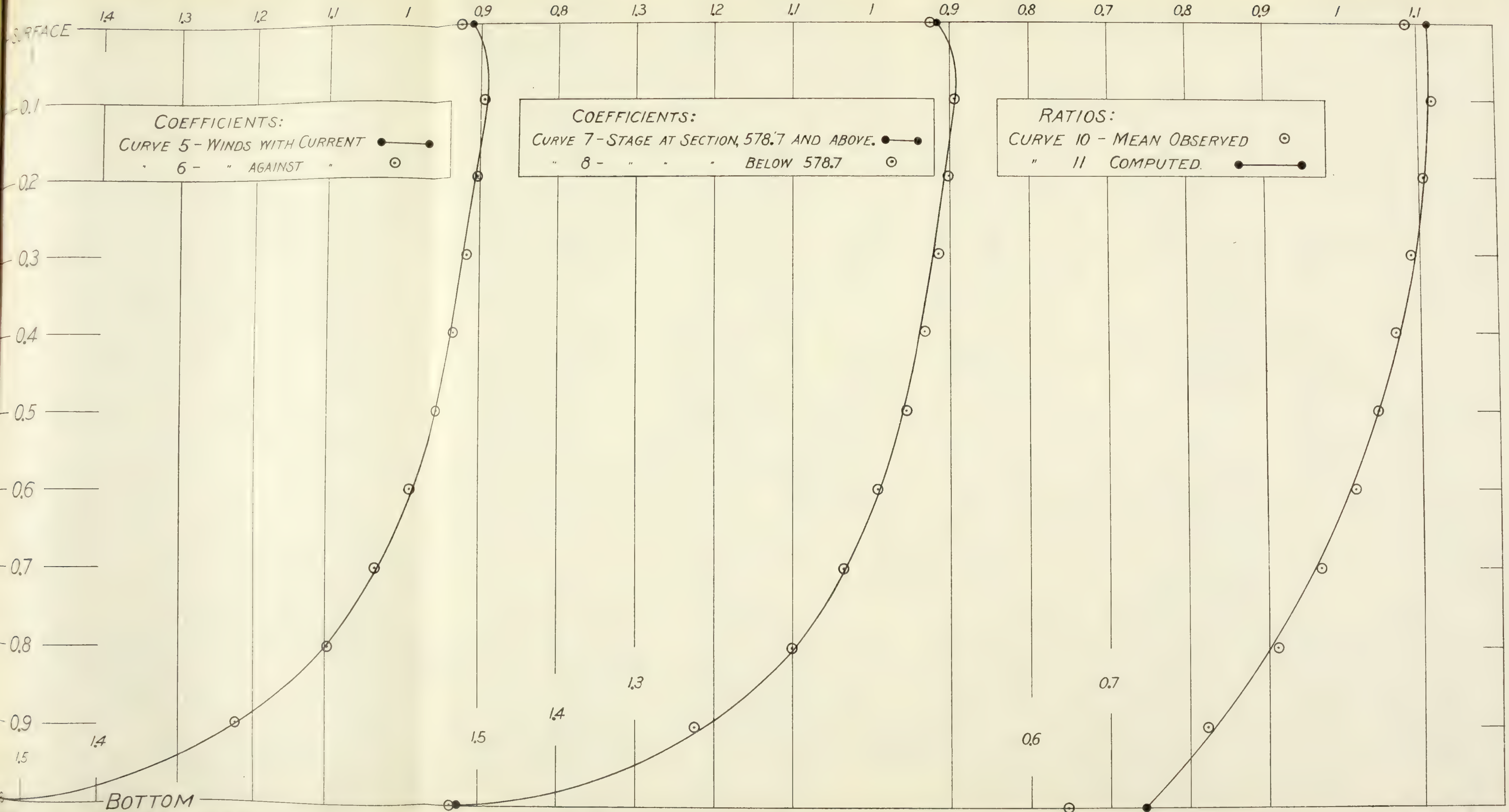
RATING OF U.S.L.S. CURRENT METER NO. 1B.
WITH SINGLE CABLE
SIXTY-EIGHT OBSERVATIONS TAKEN OCT. 6, 1899.
EQUATIONS:
CURVE: y = .0684 x² + .9503 x + .3983 for values of x less than 2.4
STRAIGHT LINE: y = 1.2483 x + .0803 for values of x greater than 2.4
Probable Error of a single observation = .014
1
2
3
4
5

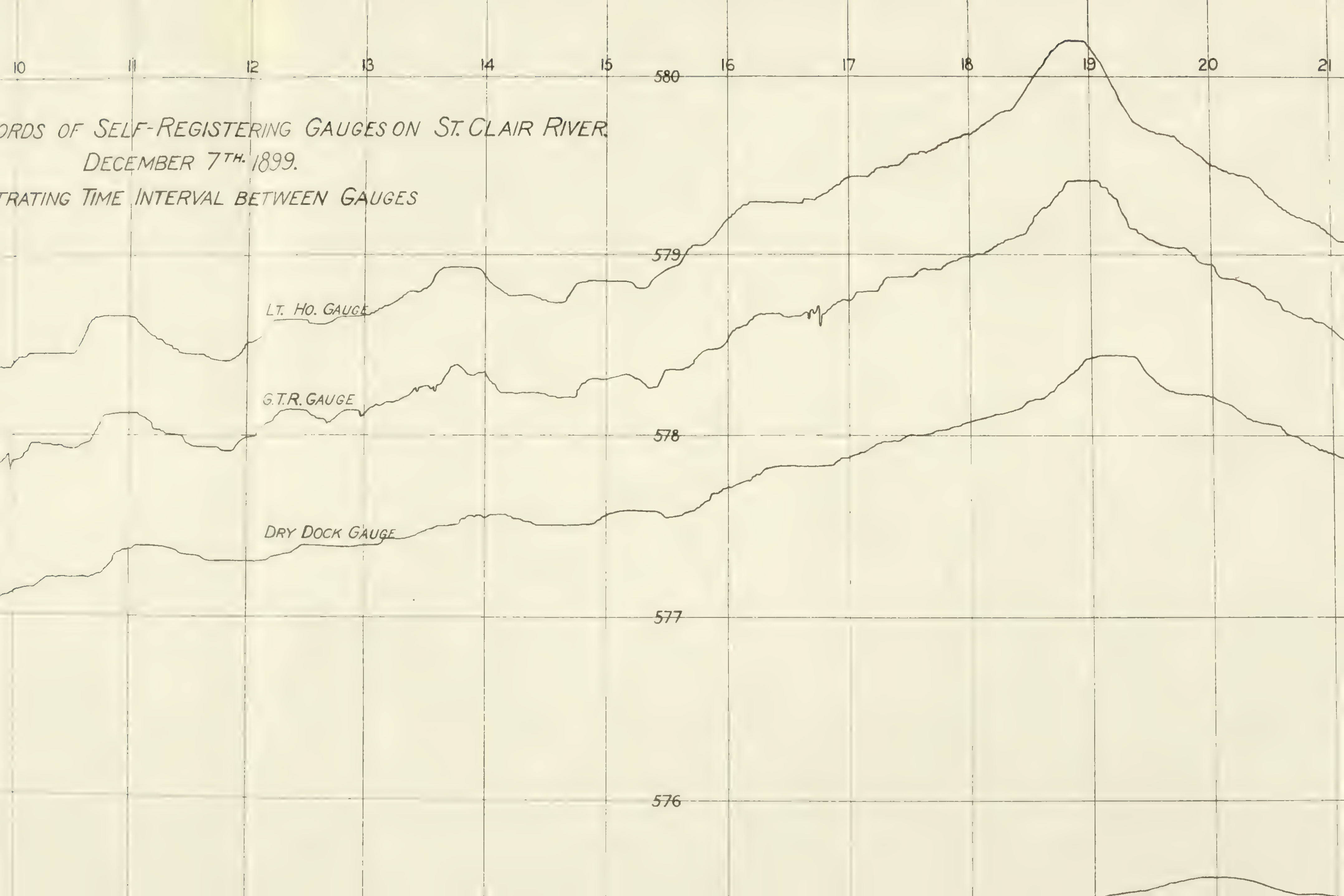
VERTICAL CURVES OF COEFFICIENTS.

Plate IV.



MEAN VERTICAL CURVES





ORDS OF SELF-REGISTERING GAUGES ON ST. CLAIR RIVER.
DECEMBER 7TH. 1899.
TRATING TIME INTERVAL BETWEEN GAUGES
LT. HO. GAUGE
G.T.R. GAUGE
DRY DOCK GAUGE
10
11
12
13
14
15
16
17
18
19
20
21
580
579
578
577
576

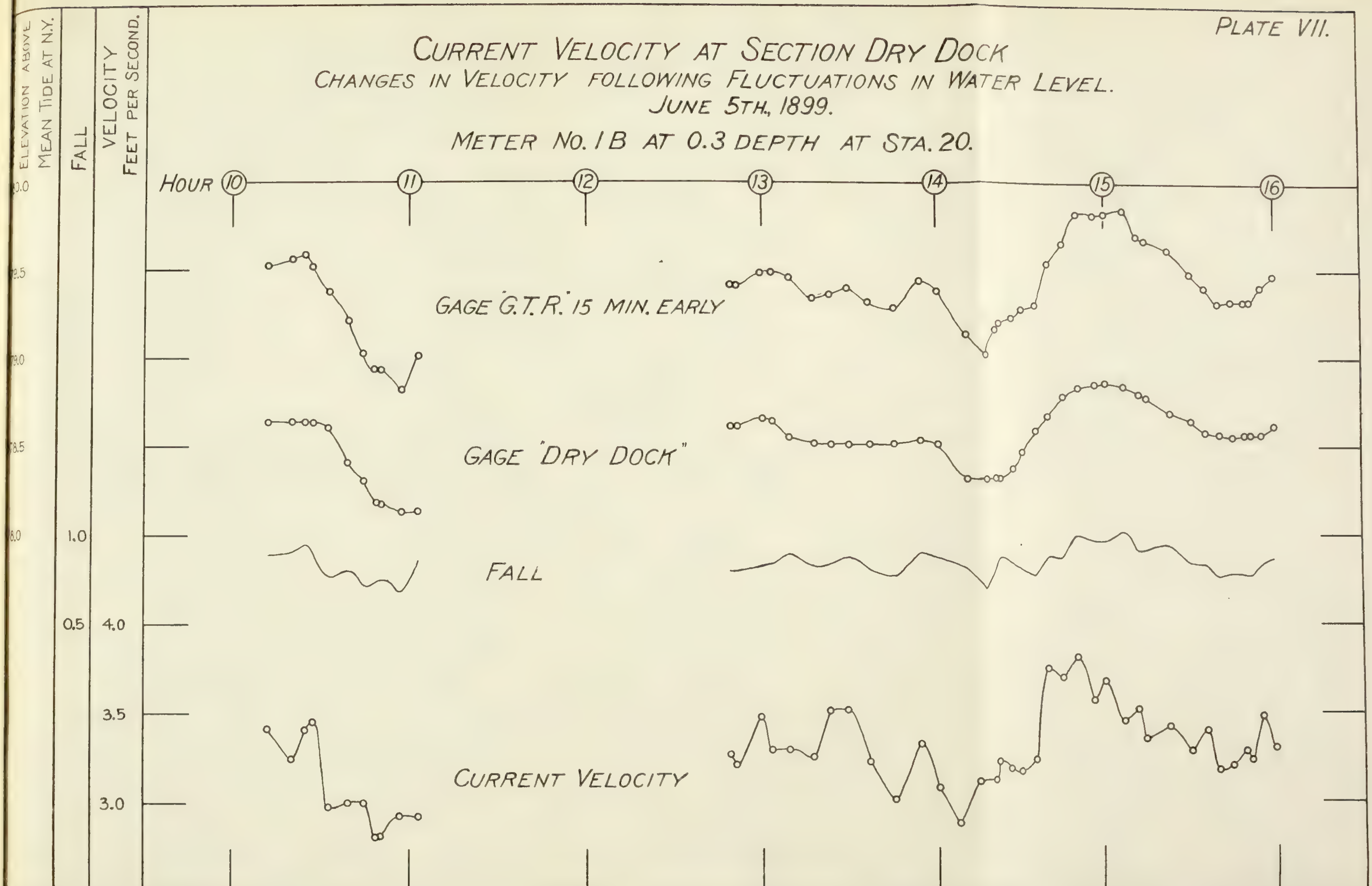
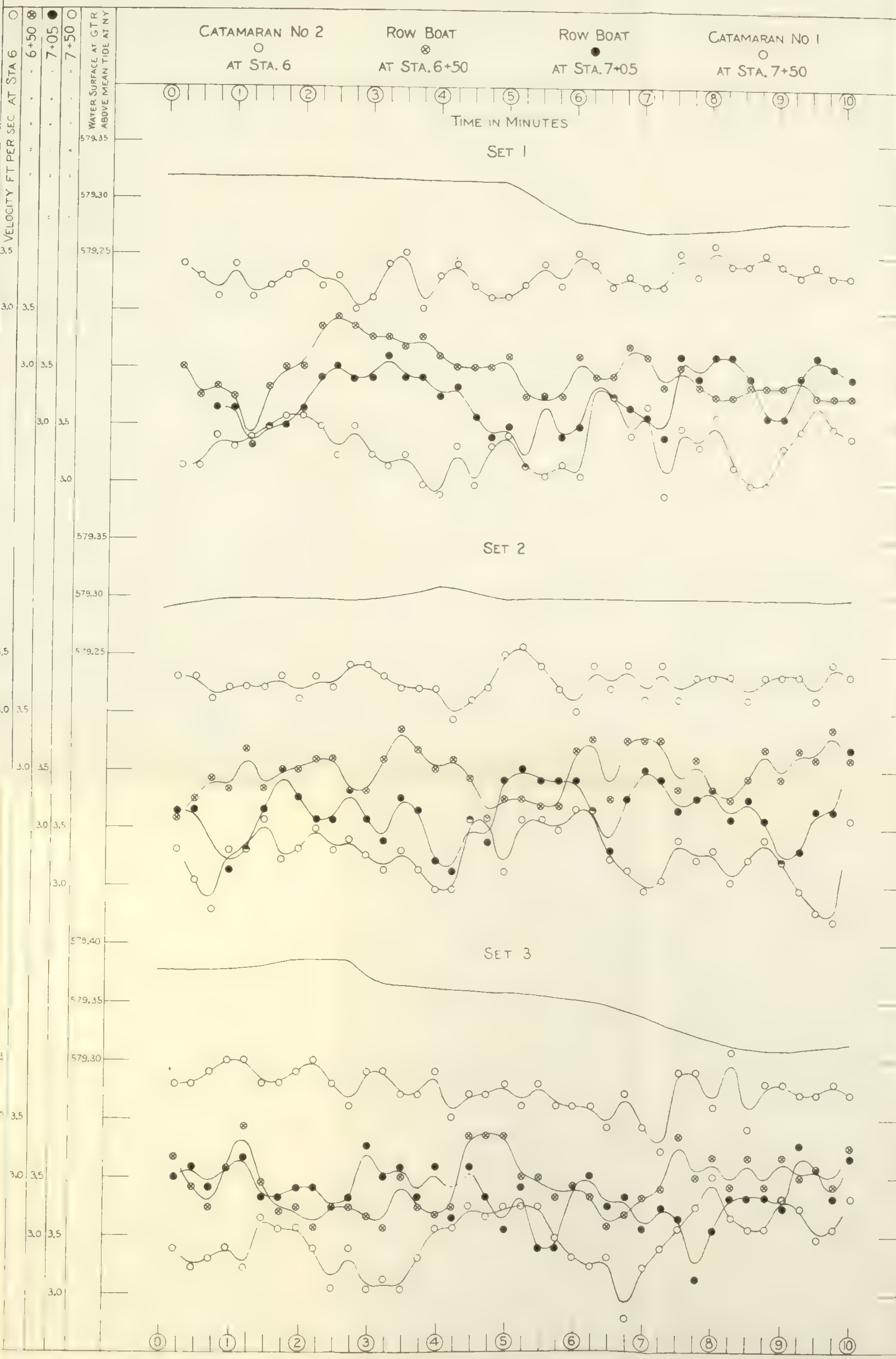


PLATE VII.
CURRENT VELOCITY AT SECTION DRY DOCK
CHANGES IN VELOCITY FOLLOWING FLUCTUATIONS IN WATER LEVEL.
JUNE 5TH, 1899.
METER NO. 1 B AT 0.3 DEPTH AT STA. 20.
ELEVATION ABOVE MEAN TIDE AT N.Y.
FALL
VELOCITY FEET PER SECOND.
HOUR
10
11
12
13
14
15
16
GAGE "G.T.R." 15 MIN. EARLY
GAGE "DRY DOCK"
FALL
CURRENT VELOCITY
1.0
0.5
4.0
3.5
3.0

Eng 56 2

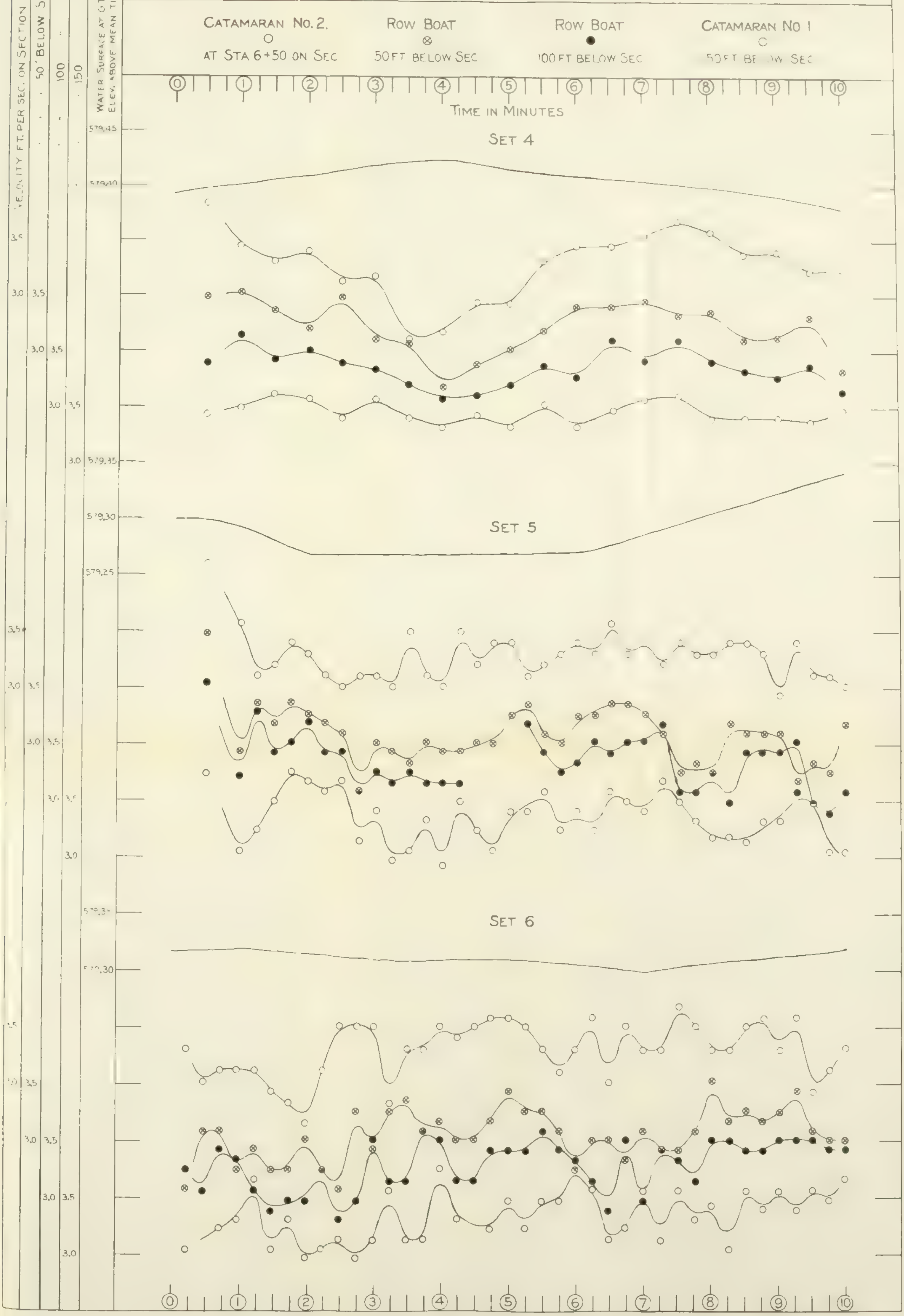
PULSATIONS OF CURRENT AT SECTION "DRY DOCK"

SIMULTANEOUS OBSERVATIONS AT POINTS 50 FT APART ACROSS STREAM



Pulsations of Current at Section "Dry Dock"

Simultaneous Observations at Points 50 ft. apart Parallel to Current



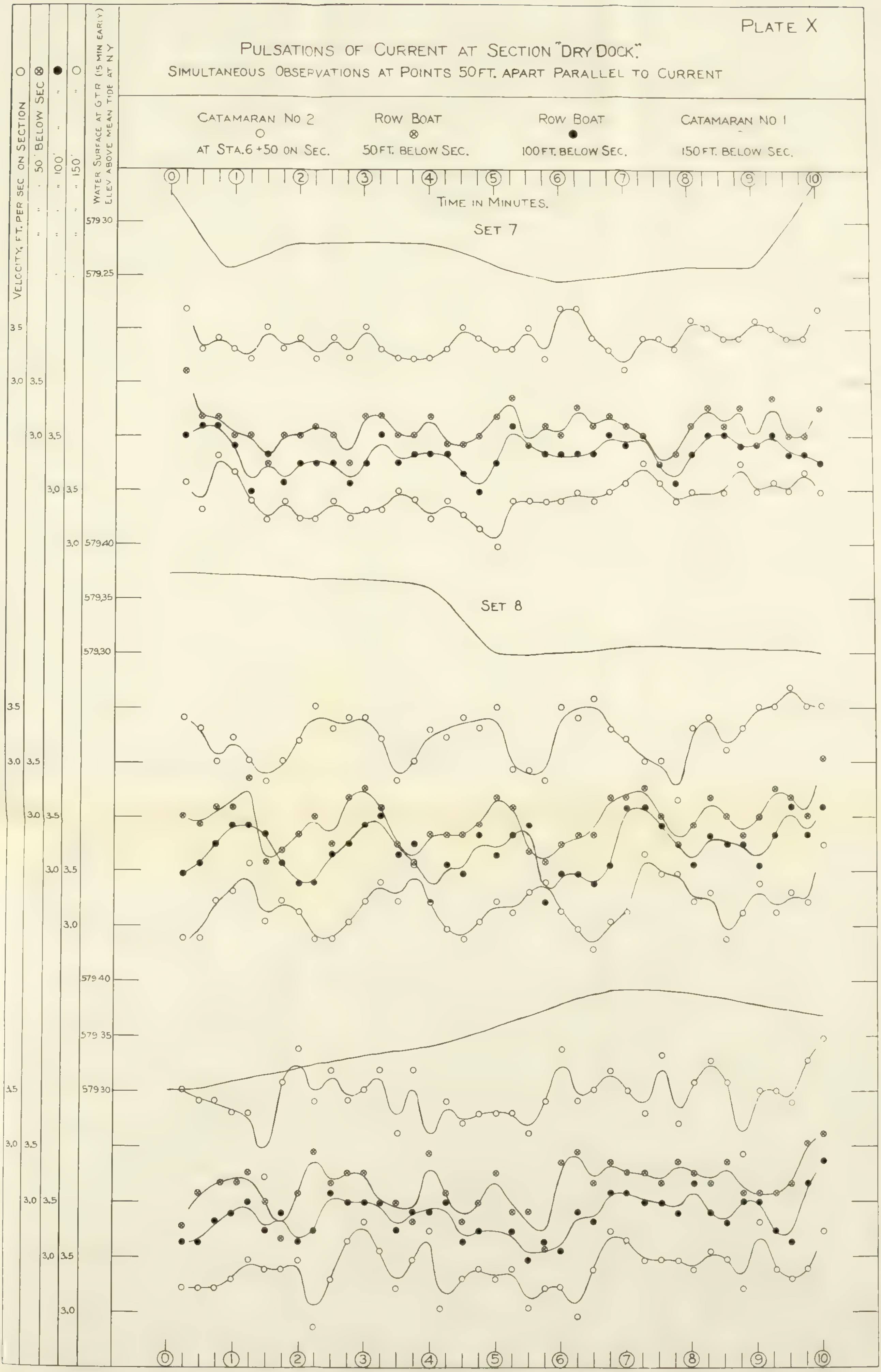


PLATE X
PULSATIONS OF CURRENT AT SECTION "DRY DOCK."
SIMULTANEOUS OBSERVATIONS AT POINTS 50 FT. APART PARALLEL TO CURRENT
CATAMARAN NO 2 ○ AT STA. 6 + 50 ON SEC.
ROW BOAT ⊗ 50 FT. BELOW SEC.
ROW BOAT ● 100 FT. BELOW SEC.
CATAMARAN NO 1 150 FT. BELOW SEC.
TIME IN MINUTES.
SET 7
SET 8
VELOCITY, FT. PER SEC ON SECTION ○
50' BELOW SEC ⊗
100' ●
150' ○
WATER SURFACE AT G T R (15 MIN EARLY) ELEV ABOVE MEAN TIDE AT N Y
579.30
579.25
579.40
579.35
3.5
3.0

Eng 56 2

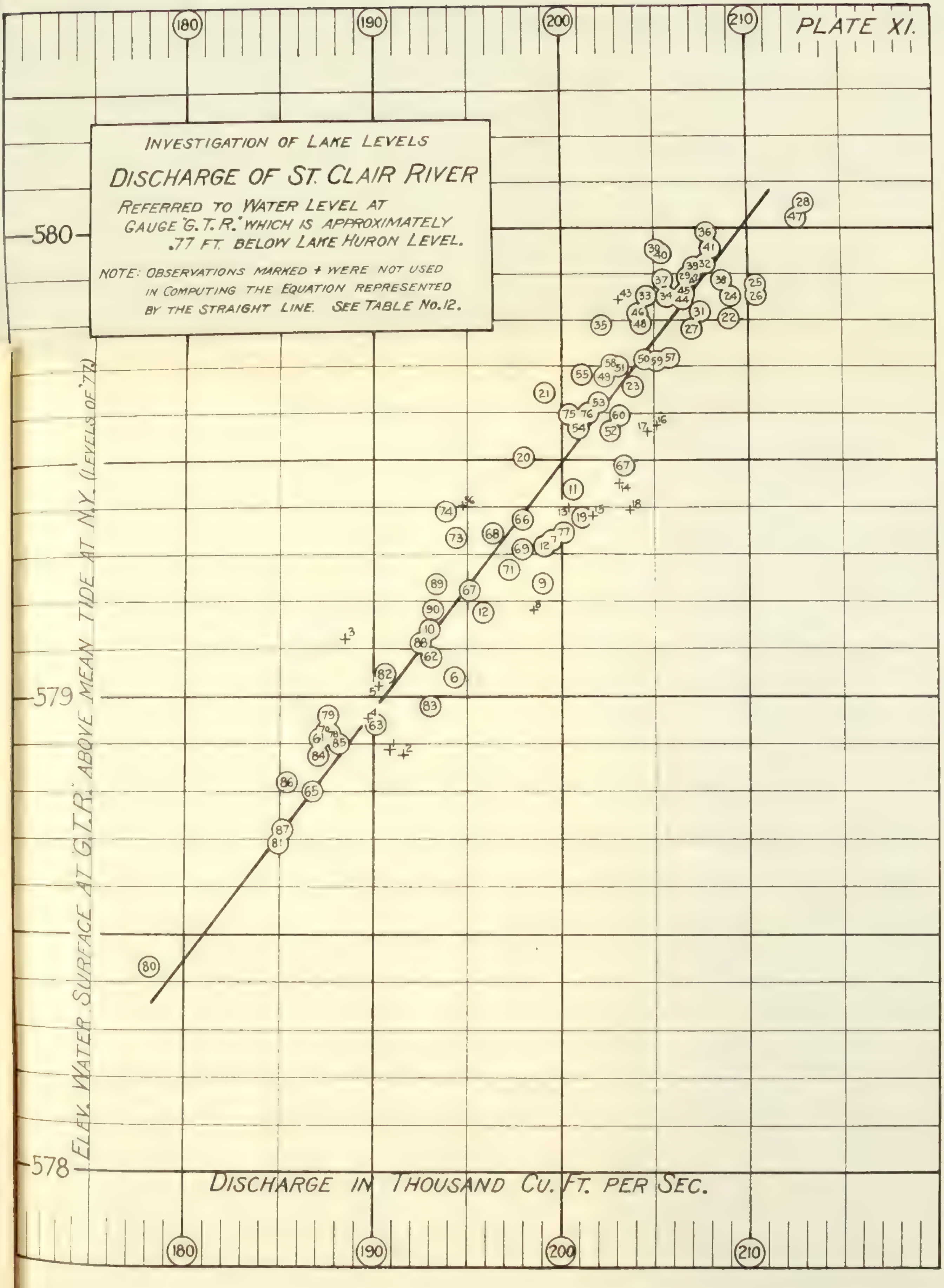

INVESTIGATION OF LAKE LEVELS
DISCHARGE OF ST. CLAIR RIVER
REFERRED TO WATER LEVEL AT GAUGE "G.T.R." WHICH IS APPROXIMATELY .77 FT. BELOW LAKE HURON LEVEL.
NOTE: OBSERVATIONS MARKED + WERE NOT USED IN COMPUTING THE EQUATION REPRESENTED BY THE STRAIGHT LINE. SEE TABLE No. 12.
ELEV. WATER SURFACE AT "G.T.R." ABOVE MEAN TIDE AT N.Y. (LEVELS OF '77)
DISCHARGE IN THOUSAND CU. FT. PER SEC.
180
190
200
210
580
579
578

Plate XII

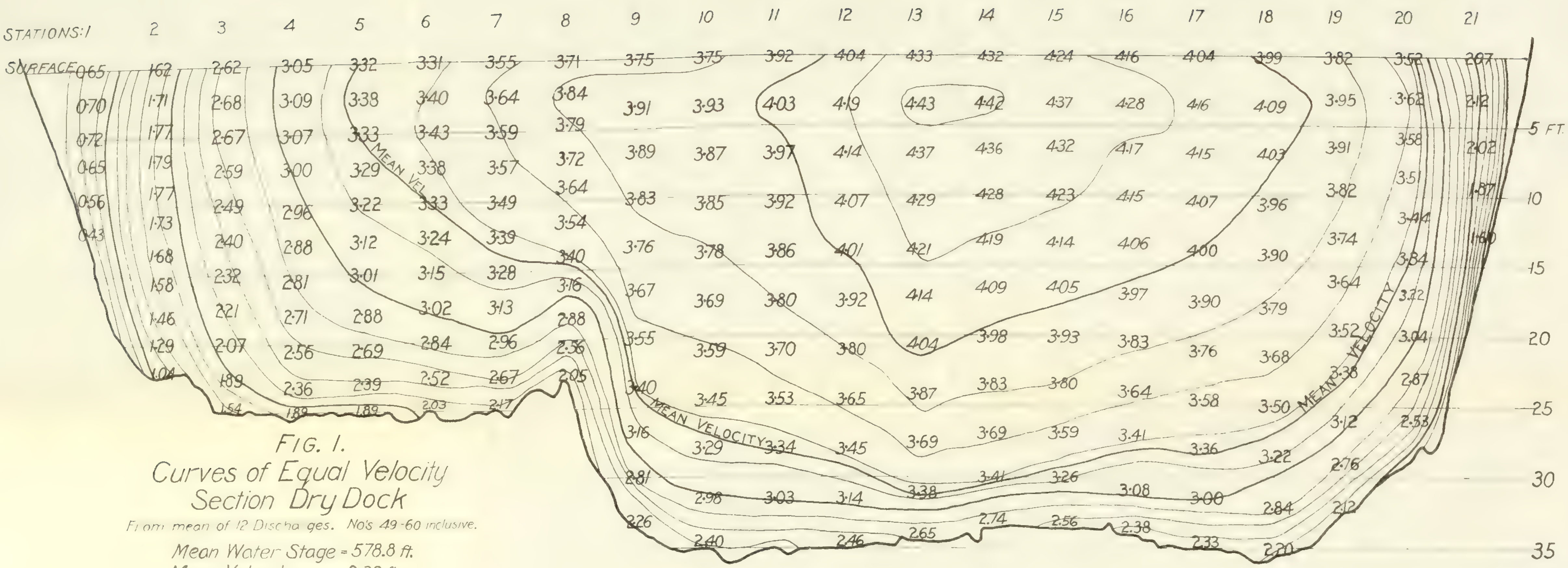


FIG. 1.
Curves of Equal Velocity
Section Dry Dock
From mean of 12 Discharges. No's 49-60 inclusive.
Mean Water Stage = 578.8 ft.
Mean Velocity = 3.33 ft. sec.

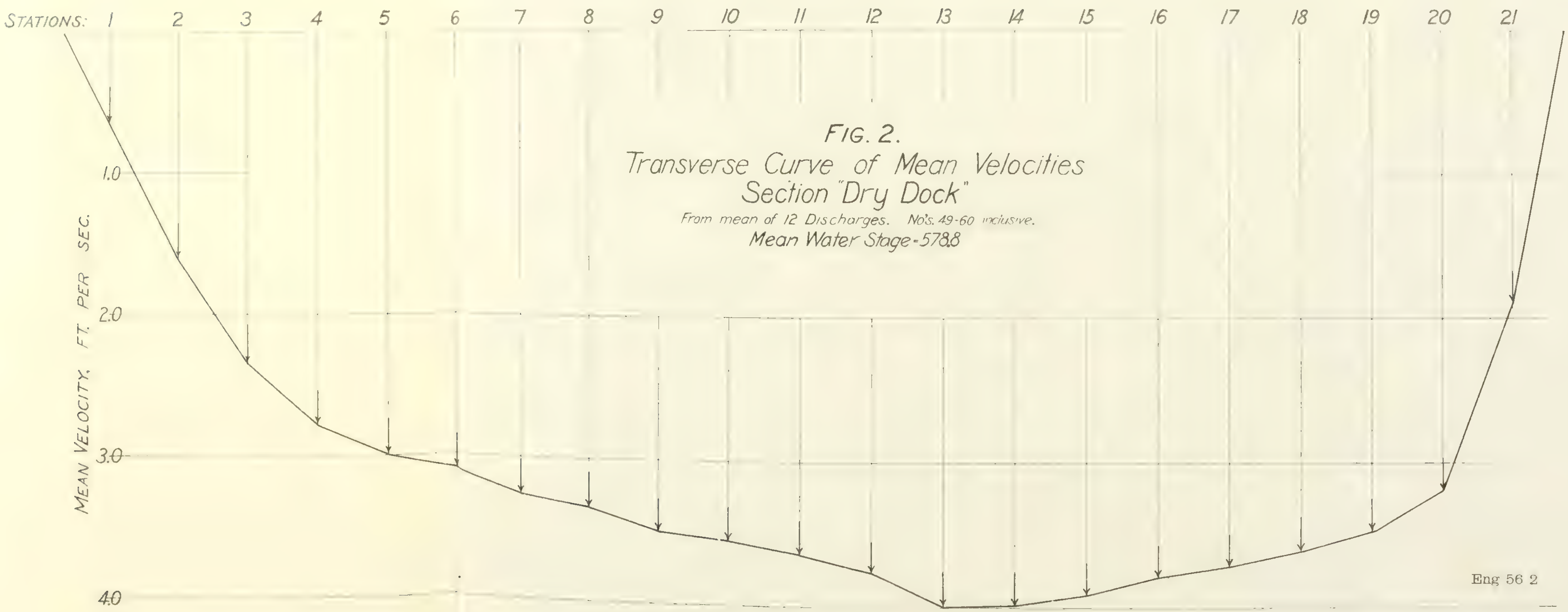


FIG. 2.
Transverse Curve of Mean Velocities
Section "Dry Dock"
From mean of 12 Discharges. No's. 49-60 inclusive.
Mean Water Stage = 578.8

FALL IN ST. CLAIR RIVER SEASON OF 1899 PLATE XIII

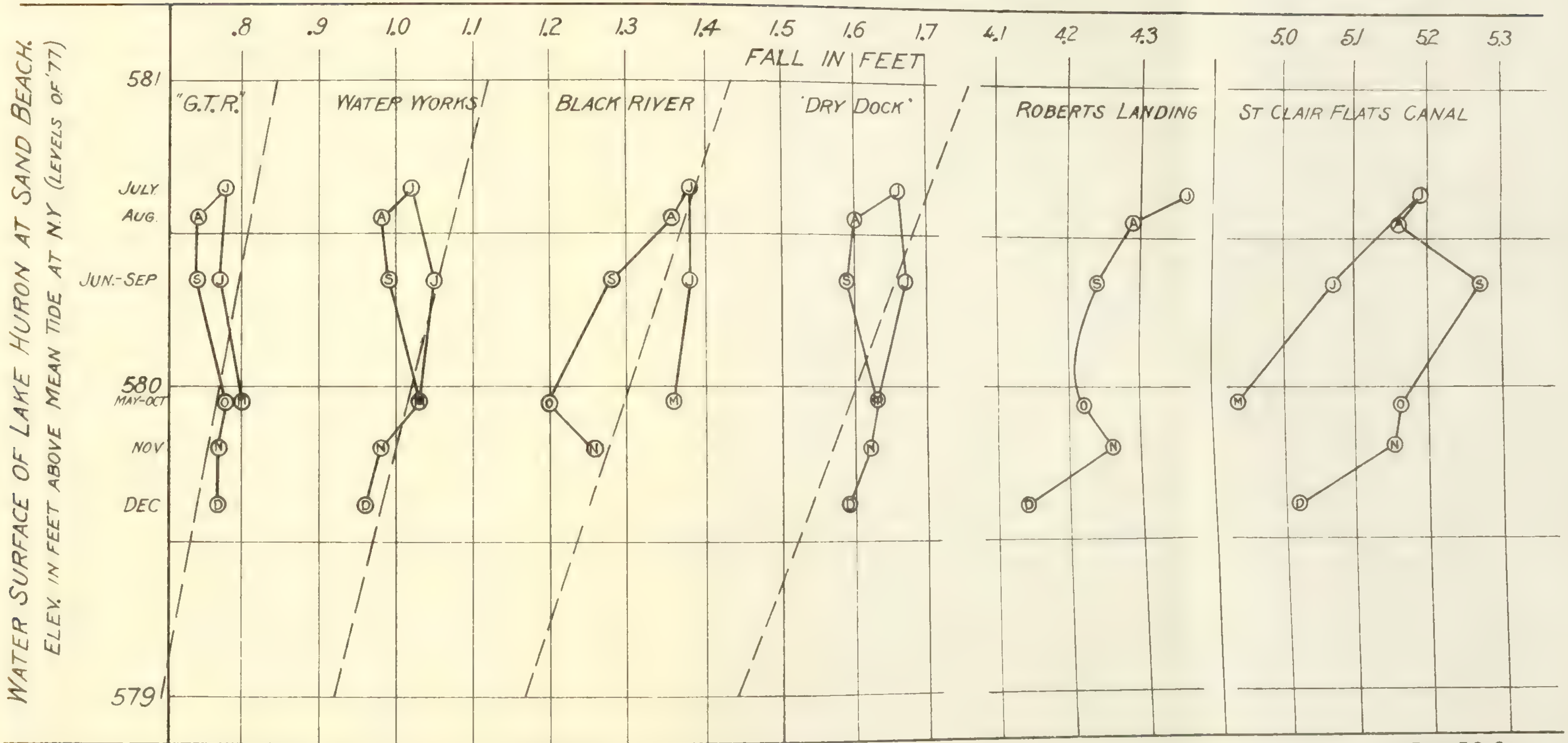


Plate XIV.

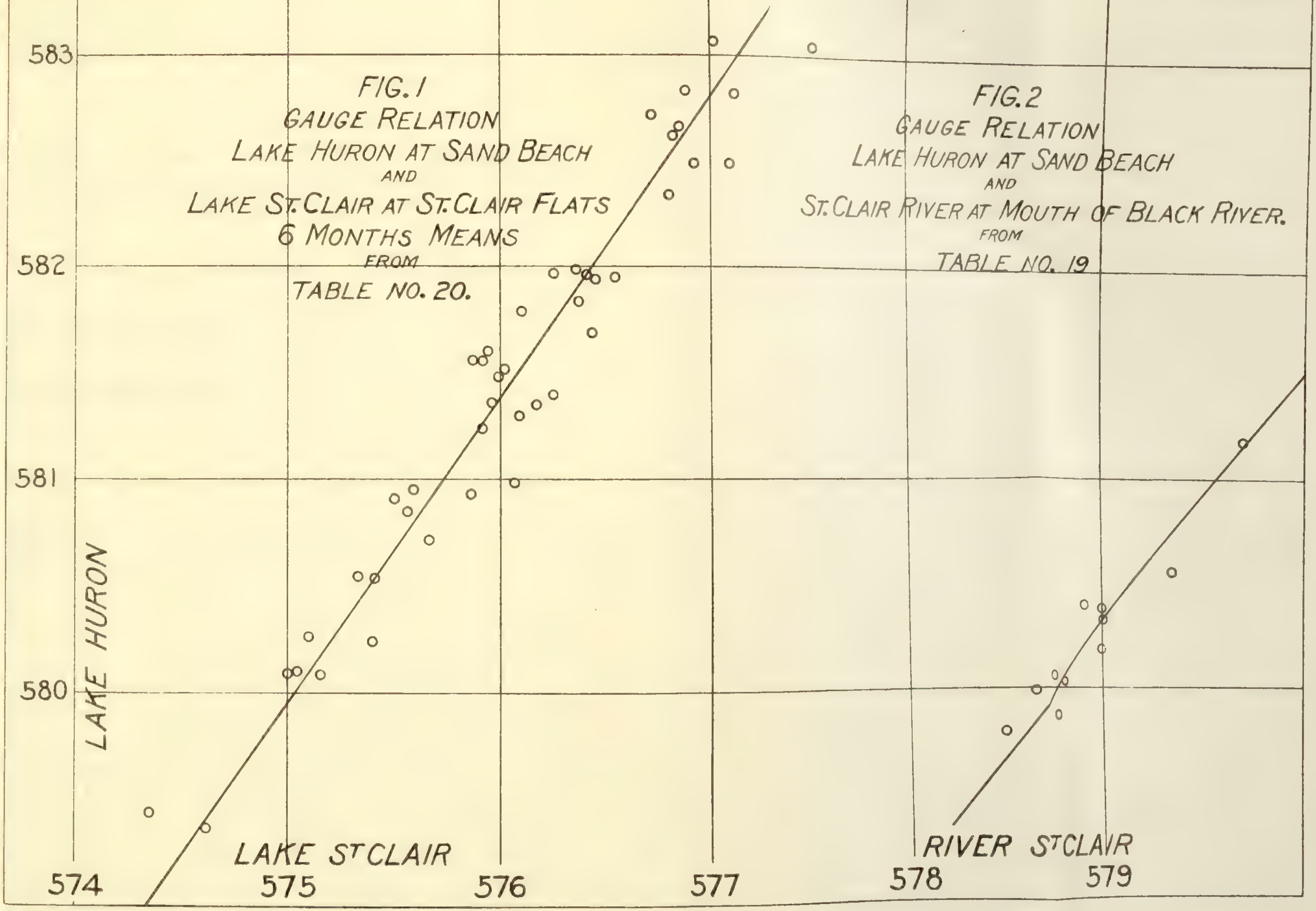
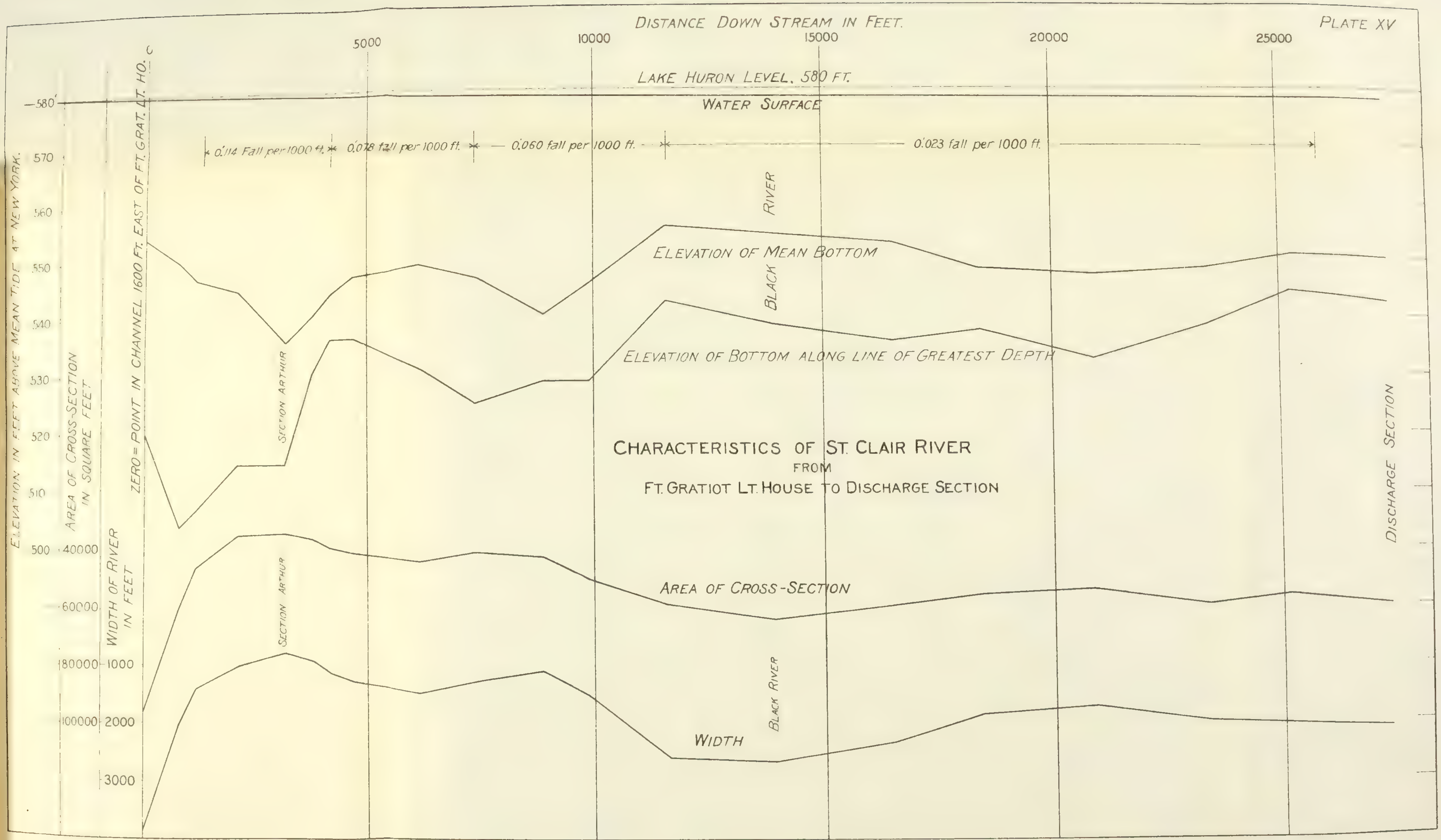


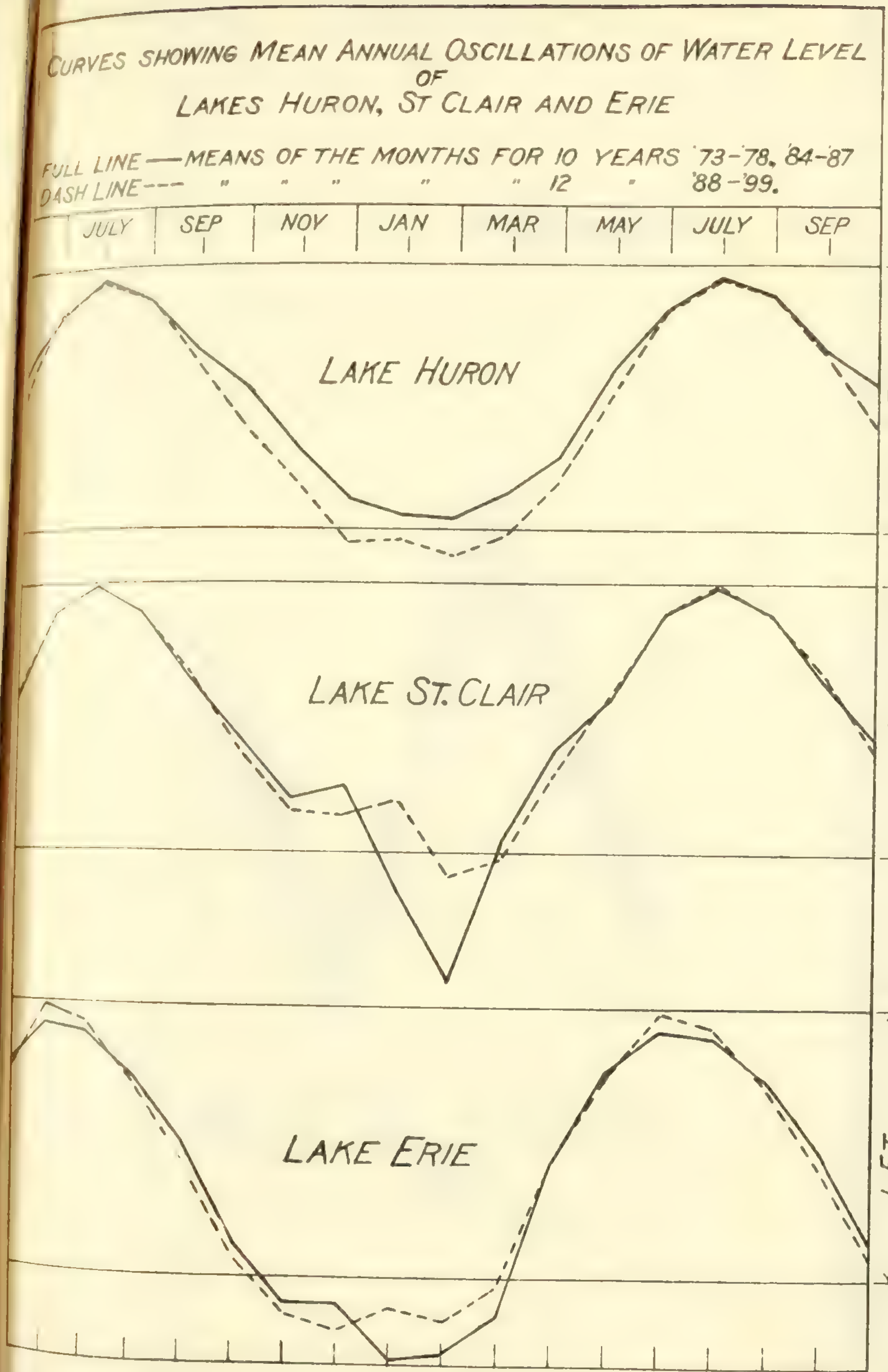
FIG. 1
GAUGE RELATION
LAKE HURON AT SAND BEACH
AND
LAKE ST. CLAIR AT ST. CLAIR FLATS
6 MONTHS MEANS
FROM
TABLE NO. 20.
FIG. 2
GAUGE RELATION
LAKE HURON AT SAND BEACH
AND
ST. CLAIR RIVER AT MOUTH OF BLACK RIVER.
FROM
TABLE NO. 19
583
582
581
580
LAKE HURON
LAKE ST CLAIR
RIVER ST CLAIR
574
575
576
577
578
579

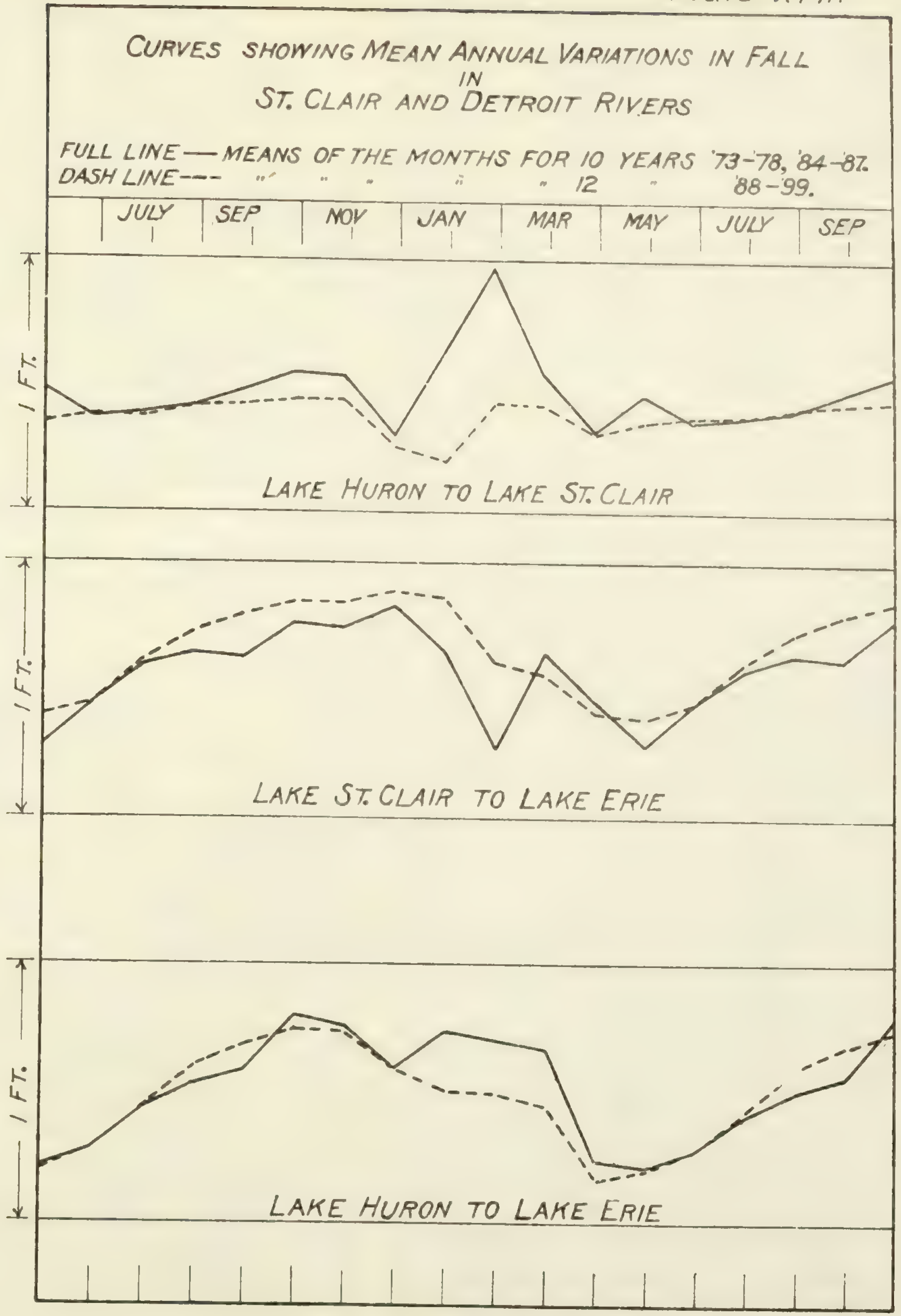
FOLD OUT



CHARACTERISTICS OF ST. CLAIR RIVER
FROM
FT. GRATIOT LT. HOUSE TO DISCHARGE SECTION


WATER LEVELS (6 MO. MEANS) FROM TABLE No. 20.
LAKE HURON
LAKE ST CLAIR
LAKE ERIE
IN ST. CLAIR RIVER
L IN DETROIT RIVER


CURVES SHOWING MEAN ANNUAL OSCILLATIONS OF WATER LEVEL
OF
LAKES HURON, ST CLAIR AND ERIE
FULL LINE — MEANS OF THE MONTHS FOR 10 YEARS '73-'78, '84-'87
DASH LINE --- " " " " 12 " '88-'99.
JULY
SEP
NOV
JAN
MAR
MAY
JULY
SEP
LAKE HURON
LAKE ST. CLAIR
LAKE ERIE
1 FT.
1 FT.
1 FT.


CURVES SHOWING MEAN ANNUAL VARIATIONS IN FALL
IN
ST. CLAIR AND DETROIT RIVERS
FULL LINE — MEANS OF THE MONTHS FOR 10 YEARS '73-'78, '84-'87.
DASH LINE --- " " " " " 12 " '88-'99.
JULY
SEP
NOV
JAN
MAR
MAY
JULY
SEP
LAKE HURON TO LAKE ST. CLAIR
LAKE ST. CLAIR TO LAKE ERIE
LAKE HURON TO LAKE ERIE
1 FT.
1 FT.
1 FT.

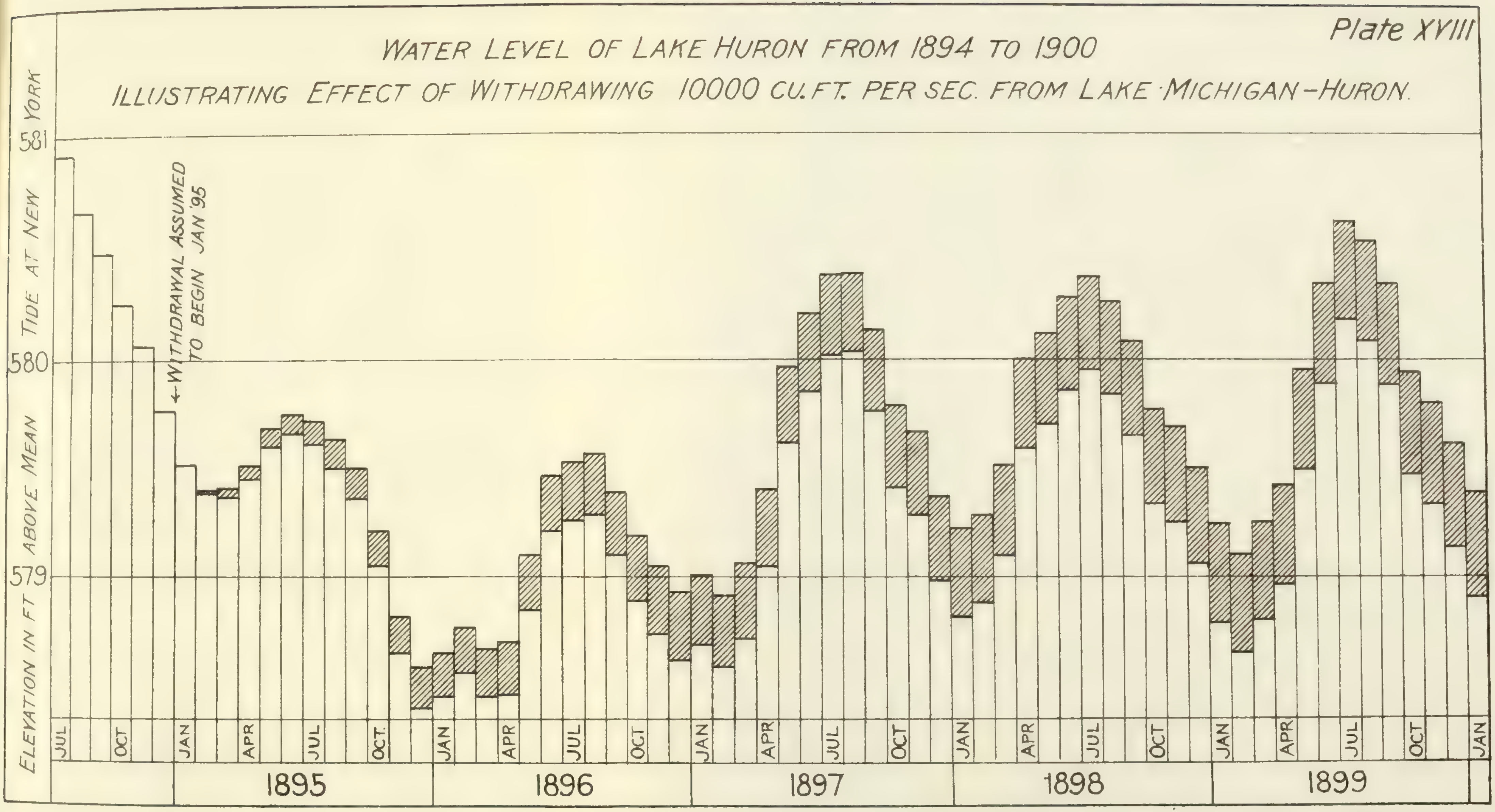


Plate XVIII
WATER LEVEL OF LAKE HURON FROM 1894 TO 1900
ILLUSTRATING EFFECT OF WITHDRAWING 10000 CU. FT. PER SEC. FROM LAKE MICHIGAN-HURON.
ELEVATION IN FT ABOVE MEAN TIDE AT NEW YORK
581
580
579
←WITHDRAWAL ASSUMED TO BEGIN JAN '95
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changes, but, as has been shown, the slope in the high-water years is greater than in low-water years.

To return to the question of the effect of the ice on the relative levels of Huron and Erie, it has been shown that the water levels give evidence of much greater disturbance of the natural slope during the winter months of the years from 1873 to 1878 and from 1884 to 1887 than during the winters of the past twelve years, and that, judged by the number of cold days in each winter, the recent years have been much less favorable for the formation of ice. The probable effect of the diminished slope at the head of the river caused by ice during the past winter has been shown to be more than 4 inches. While this effect may be overestimated in the foregoing table, there is no doubt that in the consideration of the effect of ice we are dealing with conditions which are very potent and that the lack of ice effect due to recent mild winters furnishes a plausible explanation of the present low water of Lake Huron as compared with Lake Erie. The conclusion seems to be clearly indicated that nature has provided a system of regulating works in the St. Clair River which she has neglected to use to their full capacity during recent years.

EFFECT OF ADDITIONAL DISCHARGE THROUGH INDEPENDENT OUTLET.

The effect of withdrawing from Lake Michigan-Huron a certain amount of water through an independent outlet may now be determined within the limits of accuracy of our discharge equation. It has been said that the true discharge equation is probably of a higher degree than the first. A given change in stage at high levels would doubtless result in a greater change in discharge than at low levels. Consequently the continuous withdrawal of a fixed amount per second would effect a greater subsidence of lake level in low stages than in high stages. Considering the increment of discharge per foot rise in stage to be constant and equal to 19,030 cubic foot-seconds, the ultimate effect of withdrawing, say, 10,000 cubic foot-seconds, through an independent outlet will be to lower Lake Michigan-Huron 10,000 ÷ 19,030 or 0.525 foot, about $6\frac{1}{4}$ inches. If in very low water the increment of discharge becomes as low as 18,000 cubic foot-seconds the effect at low stage would be about 0.55 foot; and if at high stages the increment becomes as high as 22,000 cubic foot-seconds, the effect on the high stage would be 0.45 foot. When the lakes are below the mean stage the ultimate effect of the withdrawal of 10,000 cubic foot-seconds is probably not less than a half foot.

The area of Lake Michigan-Huron is, approximately, 45,314 square miles. A discharge of 10,000 cubic foot-seconds is equivalent to 0.0205 foot depth over the entire lake surface. The rate of fall, then, due to withdrawal of this amount of water alone would be 0.0205 foot per month, and to lower the lake 0.525 foot would require 25.6 months; but as soon as the lakes begin to fall on account of this additional discharge the discharge through the natural outlet will be diminished on account of the lower stage, and the rate of fall will thereby be diminished. The mathematical expression of this law, giving the net change after *n* months, is rather complicated and need not be given here. The results derived from it are given in the following table:

TABLE No. 23.—*Fall in level of Lake Michigan-Huron due to withdrawal of 10,000 cubic foot-seconds through independent outlet.*

	Foot.	Per cent.
Total effect	0.525	100
At end of first year	.199	38
At end of second year	.323	62
At end of third year	.400	76
At end of fourth year	.448	85
At end of fifth year	.478	91

One-half of the total effect would have been realized at the end of eighteen months, three-quarters after three years, and nine-tenths after five years. On Plate XVIII are shown the monthly mean elevations of water surface of Lake Huron from July, 1894, to January, 1900, as it actually existed, and the elevations that would have been found had the withdrawal of 10,000 cubic foot-seconds been continued since January 1, 1895.

In closing this report I wish to express my appreciation of the services of Recorders Murray Blanchard, W. J. Graves, and A. H. Horton, who have been energetic and painstaking in the discharge of their duties.

Very respectfully, your obedient servant,

L. C. SABIN, *Assistant Engineer.*

Mr. E. E. HASKELL,
Assistant Engineer.

III 2.

PRESERVATION OF BENCH MARKS ALONG THE ERIE CANAL.

REPORT OF CAPT. GRAHAM D. FITCH, CORPS OF ENGINEERS.

United States Engineer Office,
Oswego, N. Y., July 4, 1900.

General: I have the honor to transmit herewith annual report on Survey of Northern and Northwestern Lakes, preservation of United States bench marks on Erie Canal, for the fiscal year ending June 30, 1900.

Very respectfully, your obedient servant,

Graham D. Fitch,
Captain, Corps of Engineers.

Brig. Gen. John M. Wilson,
Chief of Engineers, U. S. A.

The retransfer of 16 bench marks which were threatened with obliteration by the enlargement of the Erie Canal by the State of New York was completed in July, 1899.

III 3.

ANNUAL WATER LEVELS OF THE NORTHERN AND NORTHWESTERN LAKES.

Tridaily observations were made at Charlotte and Oswego, N. Y., on Lake Ontario; at Erie Harbor, Pennsylvania; Ashtabula and Cleveland, Ohio, on Lake Erie; at Milwaukee, Wis., on Lake Michigan; at Sand Beach, Mich., on Lake Huron; and Sault Ste. Marie and Marquette, Mich., on Lake Superior, from July 1, 1899, to June 30, 1900; and at Escanaba, Mich., on Green Bay, from July 1, 1899, to January 15, 1900, and from April 1 to June 30, 1900.

The accompanying table is a continuation of that published in the Annual Report of the Chief of Engineers for 1899, Part VI, page 3860:

Station.	1899.						1900.					
	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Charlotte	3.16	3.56	4.07	4.40	4.52	4.72	4.58	4.47	4.03	3.44	3.16	3.11
Oswego	3.18	3.64	4.14	4.57	4.67	4.74	4.59	4.28	3.99	3.30	3.11	3.19
Erie	2.50	2.86	3.10	3.41	3.43	3.17	3.41	3.21	3.09	2.76	2.58	2.32
Ashtabula	2.55	2.77	3.00	3.24	3.20	3.16	3.24	3.04	2.80	2.50	2.25	2.41
Cleveland	2.65	2.90	3.26	3.50	3.49	3.77	3.75	3.54	3.19	2.88	2.72	2.64
Milwaukee	3.70	3.78	3.92	4.25	4.43	4.93	5.08	4.97	4.80	4.67	4.43	4.32
Escanaba	3.79	3.83	4.15	4.28	4.64	4.97	*a*5.10	(*b*)	(*b*)	4.84	4.66	4.50
Sand Beach	3.70	3.79	3.99	4.40	4.54	4.73	4.96	4.95	4.92	4.80	4.65	4.48
Marquette	2.13	1.97	1.81	2.00	2.11	2.32	2.69	2.87	3.09	3.19	3.02	2.96
Sault Ste. Marie	2.19	2.04	1.85	2.19	2.15	2.31	2.88	2.97	3.15	3.14	2.94	2.98

a January 1 to 15, inclusive. *b* No reading; bay frozen over.

APPENDIX J J J.

IMPROVEMENT OF THE YELLOWSTONE NATIONAL PARK, INCLUDING THE CONSTRUCTION, REPAIR, AND MAINTENANCE OF ROADS AND BRIDGES.

REPORT OF CAPT. H. M. CHITTENDEN, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1900.

UNITED STATES ENGINEER OFFICE,
Sioux City, Iowa, July 2, 1900.

GENERAL: I have the honor to transmit herewith report upon improvement of Yellowstone National Park for the fiscal year ending June 30, 1900.

Very respectfully, your obedient servant,

H. M. CHITTENDEN,
Captain, Corps of Engineers, U. S. A.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

IMPROVEMENT OF YELLOWSTONE NATIONAL PARK.

At the close of the last fiscal year the programme of work in the Park for the ensuing season had been laid out and operations were begun as soon as the appropriation was available. The amount of the appropriation being insufficient for the work that needed to be done, it was thought best to concentrate it as far as possible on a single portion of the work and do that thoroughly, rather than scatter it in several places. After consulting with those who are best acquainted with the needs of the Park road system, it was concluded that the work which was most urgently required was the construction of a new road from Mammoth Hot Springs to the top of what is called the Golden Gate Hill.

This hill rises about 1,000 feet above the level at the Mammoth Hot Springs hotel in a distance of 4 miles. It has always been one of the most serious obstacles to travel in the Park. The first road built up the hill was what is called in that country a wagon trail; that is, a primitive road without any grading to speak of, but simply a track capable of giving passage to wagons. It reached the upper plateau through Snow Pass, about 2 miles west of Kingman Pass, in which the present road lies, and 2 miles distant from Mammoth Hot Springs. The road was almost impassable on account of its excessive grades and was abandoned as soon as the Park work was systematically taken up.

The next road was located by Captain Kingman through the pass, where the waters of Glen Creek flow from the plateau above to the

valley of the Gardiner. This pass was lower than Snow Pass and more in the direct line of the road. The Golden Gate Canyon, which constitutes the pass, was exceedingly difficult to build through and took so large a part of the funds available that only a small amount could be used on the 3 miles between Golden Gate and Mammoth Hot Springs.

The direct line between these two points, and the one where the best grades and most interesting scenery were to be found, lay through an excessively difficult tract of limestone rock. This singular formation, to which local usage has given the name "hoodoos," is quite unlike any other to be seen in the Park, if, indeed, its like is to be found anywhere else in the world. It has the appearance of unslacked common lime, and the action of fire on it is to reduce it to a white powder very much like the product obtained from slacking lime. The rock abounds in every conceivable variety of form and size, from the smallest chip to immense masses a hundred or more feet through. These masses have been thrown by some natural convulsion into a most confused and irregular arrangement in which all trace of the original positions is lost. The scenic effect, while extremely interesting, is of a weird and unusual character quite unlike anything else in the Park.

This formation varies in width from a quarter to a half a mile and is wholly impassable by wagons or on horseback. Even on foot it is a difficult and laborious matter to get through. To carry a road through it was too expensive a matter to be attempted with the funds which Lieutenant Kingman had at his disposal, and it was necessary to follow a line further east, near the immediate valley of Glen Creek, where the rough formation largely disappears. But in so doing it was impossible to avoid several very heavy grades, ranging from 10 to 21 feet in the hundred. These steep pitches have always been a great drawback to the road and the source of much danger to heavily loaded coaches going in either direction. It has been found impracticable to maintain the road in good condition. The action of brakes and rough locks in descending and of the horses' shoes in ascending was to dig up whatever surfacing material might be placed on the bed of natural rock, while the rain would wash this material to the bottom of the hill or the wind would blow it away. The result was that for a good portion of the time the rough rock under the roadbed would be exposed, making the road both uncomfortable and dangerous.

It has been intended for several years to change this location, but the demands for new work elsewhere and the difficulty of finding a better route have hitherto prevented it. In looking over the entire situation at the beginning of the present season it was considered that this work was quite as urgent as any other remaining to be done in the Park. It was accordingly decided to take it up at once and not undertake any other work until the balance remaining from the completion of this could be known.

In the selection of a route the natural conformation of the ground over the greater part of the distance led to an easy decision. The former road passed over a considerable elevation in the vicinity of the old military post and then dropped down into a valley, losing about 50 feet of grade which had to be overcome later on. It was decided to commence the new location at the top of this rise by keeping to the side of the hill and then commence the general ascent at once. This took the road across the foot of the Hot Springs formation and by a circuitous line carried it to the top of the hill immediately in rear of

the great spring. For this distance the road also serves the purpose of giving a convenient local driveway to the top of the Mammoth Hot Springs formation.

For about a mile above the top of Formation Hill the location of the road was a simple matter, as there was natural and easy grade all the way. From there on to the "Hoodoos" the choice of route was more difficult. The location was mainly on very steep slopes, requiring a great deal of heavy side cutting, and the work was costly. The position, however, is such as to give a wide and unobstructed view over the entire Gardiner Valley and to the mountains beyond.

Thus far the gradients range from 3 to 8 per cent, with a short pitch running up to 8.5 per cent.

The choice of routes through the "Hoodoos" was the result of a careful search over the entire belt that lay within the possible range of the road. The line finally selected gives a nearly level grade through the entire distance of 1,800 feet. The cuts and fills very nearly offset each other, and the cost of the work, though heavy, was reduced to a minimum.

Leaving this rocky tract, the road descends at a slight grade to the head of a ravine about 1,000 feet distant, and then ascends by a grade of from 3 to 7 per cent, until it joins the old road a little below Golden Gate Bridge. The introduction of a descending grade on the way up the hill was for the purpose of utilizing some work which had been done the previous year. A new location had then been selected, following pretty closely the old line, and considerable work had been done at the upper end. This location did not seem to be a sufficient improvement upon the old to justify the great cost of construction, and it was accordingly abandoned, except at the upper end, and the location of the present road was changed, from what it would have been, sufficiently to save this work.

Mr. C. E. Sherman, United States assistant engineer, was placed in charge of the technical work on this line, and commenced the definite location June 17. The entire line was accurately laid out with regular grades and curves, and in all respects as carefully done as it would be if intended for a railroad grade.

On July 5 the work of construction was commenced, and was prosecuted vigorously from that time on with three large parties. The road was opened to travel on September 10. The whole length of this new road is 16,500 feet. The amount of solid rock excavated through the "Hoodoos" was about 2,500 yards. The excavation in other parts of the road amounted to about 15,000 cubic yards of rock, clay, and loam.

But three culverts were required. One of these was put in with stone and the other two were of 20-inch cast-iron pipe set in mortar.

There are no bridges.

Next to the "Hoodoos" section, the most difficult piece of work was that at the foot of Mammoth Hot Springs formation. This stretch of road was about 1,000 feet long, and ran directly over the hard surface of the deposit. The water from the springs flows down along the entire distance, and it was necessary to cut a ditch above the road. The cut was made about 18 inches wide and 6 to 12 inches deep, and carries all the water to a single point, where it is let through the road in a pipe culvert.

It was found before the work on the Golden Gate Hill was completed that it would be possible to undertake some additional work, and accord-

ingly a start was made on a proposed new road through the Gardiner Canyon. As in the case of the Golden Gate road, lack of funds at the time that this road was originally located compelled the adoption of the line which could be constructed at the smallest possible cost. It was placed along the right bank of the river under a high overhanging cliff of very unstable rock. It has never been possible to maintain this road, owing to the quantity of rock that falls down from the cliff, and the mud and débris that wash from the slopes during storms. The road has always been considered a dangerous one, and has been the most troublesome in the Park. It has long been the intention to change it as soon as money should be available. The only change possible is to put the road on the other side of the river, and this will necessitate building, in part, in the stream. As this portion of the river has a slope of 3 to 4 feet in the hundred, it is extremely torrential in character and will require careful construction to hold the road. The new work will therefore be very costly. Four new bridges are required, and it is expected that the whole work will cost not much less than $15,000.

It was decided to put in the lower of these two bridges during the past season, because the existing bridge which it was to replace was becoming unsafe.

The bridges in the Park have always heretofore been constructed of wood, and although they have stood exceedingly well, it was believed to be better, in replacing them as they wear out, to put in steel bridges with concrete abutments. In particular it was thought best to do this with those bridges which are nearest the railroad. The cost of transportation to the interior of the Park will probably cause timber to be used there for some time to come.

The necessary materials for one bridge were accordingly purchased, and it was erected early in September. One of the principal difficulties encountered, and which will hereafter be experienced in the manufacture of concrete in the Park, is the lack of good sand. The rock, being mainly volcanic, seems to be entirely worn out by the action of the water in the streams, and no deposits of sand collect. That found occasionally in banks is of inferior quality. On the present occasion a mixture of sand and gravel was obtained from the high hill at Fort Yellowstone. The proportions as found were about right for the concrete, so that it was not screened. To remove the loam, which seemed to be present in small quantity, the material was all washed. This was done at slight expense by bringing a ditch from the Gardiner about 150 feet and running it into a flume of considerable slope which emptied into a long horizontal box about 2 feet deep. The sand and gravel were shoveled from the wagons directly into the head of the flume and were carried by the stream into the box, the dirt passing off with the water. This operation served also to transport the material from the nearest accessible place for unloading to the site of the work.

The abutments were founded on the coarse gravelly bottom of the river below the reach of scour. The course of the river immediately above the bridge was trained so as to pass the bridge parallel to the abutments.

The concrete was made in the proportions of 1 to 4 (mixed sand and gravel) for the south abutment and reduced to 1 to 5 for the north. A facing of mortar of 1 to 2 strength was put in simultaneously with the concrete. The whole mixture was probably stronger than necessary, and in future work will be reduced somewhat. The result, however, is to all appearances eminently satisfactory.

The span of the bridge is 50 feet; width, clear, 15 feet; height of bottom of stringers above low water, 6 feet.

The bridge was an expensive one, as will be seen from the following exhibit:

Concrete abutments—52 yards.

Cement, 89 barrels, at $4.15, at the work		$369.35
Gravel, 57.8 yards, at $1.78		102.70
Framing		149.00
Mixing and placing		213.90
Total		834.95

Cost per cubic yard, $16.

Superstructure.

Steel work at shop	$415.00	
Steel work, freight and hauling	185.35	
Steel work erection	129.80	
Steel work painting	18.00	
		748.15
To this should be added lumber that was on hand		105.00
Total		1,688.10

This is about twice what a wooden bridge would cost in the same place. In future work of this character the cost can be reduced in several items as a result of the experience with this, but I do not think that it will be possible in any case to reduce it below $1,300 for a bridge like the one built. But, notwithstanding the greater cost, I believe the work to be more economical in the long run, while it is much more in keeping with the quality of work which it is desired to attain throughout the Park road system.

As the new bridge was placed at some distance from the old, it was necessary to build about 600 feet of the new road in order to render it available.

In the valley of the Gibbon River a substantial though cheap timber bridge was thrown across the river at the point where the main road leaves it. This is to form a part of a road extending directly down the Gibbon for the accommodation of traffic by way of the western approach, which now has to make a long detour up the Firehole River. The bridge was put in in the fall in order to take advantage of low water. The road was opened through the timber during June of the present year. It was simply made passable for wagons and will not be fully completed until a later date.

The repair work of the past season was practically finished by the end of the last fiscal year, although small parties were kept out most of the summer. The opening and repair of the roads for the season of 1900 commenced May 1. The snow fall was much lighter than that of last year and the opening consequently much earlier.

An inspection was made by the officer in charge of nearly the entire road system, June 9–12, and the roads were found to be everywhere in good condition, except that they were dusty. A very heavy wind which prevailed on the 8th blew over 100 trees across the roads, obstructing travel and destroying telegraphic communication. Fortunately this was before the tourist travel had commenced, otherwise there would have been grave danger of accident. The dead timber left from previous forest fires is now so far decayed as to be easily

blown over, and it will be a constant menace to the lives of travelers until cleared away.

The new appropriation, act of June 6, 1900, provided that $5,000 should be immediately available for repairs, and under this provision a repair party was put on the road over the Continental Divide, where some important work was in need of being done, and all the plant has been overhauled and repaired.

The cost of the repair work from the new appropriation was $3,575.92.

During the progress of the season's work numerous surveys and examinations were made by the officer in charge and by Mr. Sherman of the various portions of the road system where new work will have to be done. These included—

East Gardiner Canyon.
Road from above point to Yanceys.
Bridge site over Yellowstone at Junction Butte.
Bridge site over Lamar River.
Road past Tower Falls and over Mount Washburn.
Bridge site over Yellowstone above falls.
Cut-off from Natural Bridge to Thumb of Yellowstone Lake.
Snake River road or southern approach.
Side road around Bunsen Peak and to Middle Gardiner Falls.

Some work was done for the superintendent in the matter of erecting station houses for his patrols.

Below is a condensed statement of the cost and distribution of expenditures of the past season's work:

Statement of expenditure.

New road to Golden Gate		$15,360.38
New road in Gardiner Canyon		1,074.80
New bridge in Gardiner Canyon		1,569.56
Surveys and examinations		242.59
Upper Gibbon Bridge		55.05
Lower Gibbon Bridge and new road to west boundary		495.56
General repairs		9,984.06
Office, freight, travel, etc		5,683.36
Protection:		
To acting superintendent	$4,500.00	
Buildings and repairs	1,034.64	
		5,534.64
		40,000.00

In my last annual report I made the following statement:

It is not possible in this report to present a precise statement of the cost of the existing project since its adoption in 1883, for in the earlier years, as well as the four just past, the appropriations have gone in part to other purposes. At the close of the present season's work a complete statement of these expenditures will be worked up from the records.

During the past winter the records of the work have been gone through exhaustively, and the result is embodied in the very complete report herewith of Mr. A. E. Burns, overseer on the park work. The following is a summary of Mr. Burns's report:

Before the road work was systematically taken up under the Engineer Department in 1883 there had been appropriated in all $68,425.17 for the administration, protection, and improvement of the park. This money was disbursed under the civilian superintendents, and no record was kept of the proportion applied to the various purposes.

Very nearly all of the roads and bridges constructed at this time have been abandoned and the rest will be as soon as the present project is completed. This money, therefore, has counted nothing on the completed road system.

Since the adoption of the existing project in 1883 to and including the act of March 3, 1899, there has been appropriated $675,934.25. Of this amount there has been expended in new work $411,910.15, resulting in the construction of 191 miles of road and 80 bridges. The mean cost per mile has been $2,156. Of this work 14.5 miles have been replaced by later work, leaving a net result of 176.5 miles. There has been expended in completion and maintenance the sum of $161,320.78, an approximate average of $100 per mile per year.

There was expended on buildings during the seventeen years only $4,684.59, and on surveys $12,670.71. Administration and protection cost $85,348.02, or $5,000 per year.

From the most complete estimate that can be made of the loss due to ill-advised locations and imperfect construction on account of inadequate funds when the work was done, the loss could not have been less than $100,000, and the results now in sight could actually have been realized, under appropriations sufficient to carry on the work in the most economical way, for not more than $300,000, probably for much less.

For a complete statement of the mileage, present and prospective, of the park road system, see the report of Mr. Burns and the accompanying map.

ESTIMATES.

In my last Annual Report I presented an estimate of the cost of completing the existing project for the construction of roads and bridges in the Yellowstone National Park. The sum estimated was $300,000. A full explanation of each item of the estimate may be found in Senate Doc. No. 226, Fifty-sixth Congress, first session, pages 9 to 15. Fuller information, derived from more careful surveys made after the estimate was prepared, necessitated a slight modification in a few items. Congress at its last session extended the project by authorizing the construction of a road from the outlet of the Yellowstone Lake to the east boundary of the Forest Reserve. This work will ultimately cost, omitting the bridges over the Yellowstone River and Pelican Creek, not less than $100,000, of which $20,000 has been appropriated.

The work necessary to be done at the beginning of the fiscal year 1901 is as follows:

1. New road in Gardiner Canyon, including 3 steel bridges	$10,000
2. Road through Golden Gate Canyon, including a new bridge to replace wooden bridge around cliff, and widening road along cliff, the latter all solid rock work	15,000
3. Raising 3 miles of road in Gibbon Canyon and cutting out 1 mile of dangerous grades, also opening 4 miles of new road down the Gibbon to connect with western approach	16,000
4. Completion of 8 miles of road near Fountain Hotel	8,000
5. Completion of southern approach along Snake River, 20 miles	30,000
6. New road from West Thumb to Natural Bridge, cutting out present line around lake shore, 8 miles	16,000
7. New road from Lake Outlet to east boundary of Forest Reserve, 50 miles, at $2,000, eastern approach	100,000
8. Surfacing new road from Lake Hotel to Grand Canyon, 15 miles	15,000

9.	New road down right bank of Grand Canyon, 3 miles		$6,000
10.	New road near Grand Canyon to cut out dangerous hills		5,000
11.	New road, Canyon to Norris, 10 miles		20,000
12.	New road, Grand Canyon, via Mount Washburn and Tower Falls, to Mammoth Hot Springs, 40 miles		80,000
13.	Completion of Cooke City road, 18 miles		15,000
14.	Side roads and trails		9,000
15.	New bridges not included in above estimate:		
	Yellowstone River, to replace Baronet Bridge	$10,000	
	Yellowstone River, near falls	20,000	
	Yellowstone River, at lake outlet	10,000	
	Lamar River, to replace existing bridge	5,000	
	Pelican Creek	3,000	
	Gibbon River, two bridges	4,000	
	On Snake River road, 2 bridges	6,000	
	Cascade Creek Bridge, near Grand Canyon	5,000	
	Nez Perce Creek	2,000	
			65,000
16.	New plant		5,000
17.	New office and other buildings		10,000
	Total for completion of project		425,000
18.	Annual repairs and maintenance for season ending June 30, 1902, 150 miles at $100 per mile		15,000

It is expected that items 1 and 2 of the estimate will be removed from the list by the work of the coming season, as will also a small portion of item 7.

Following is a succinct statement of the actual condition pertaining to each item in the above estimate:

1. New road in Gardiner Canyon, including three steel bridges $10,000

This involves the relocation and reconstruction of about 1 mile of new road and the construction of three steel bridges like the one just built over the Gardiner. The present road is very dangerous and impossible to maintain on account of the unstable cliffs which overhang it and drop rock into the road at every storm. It was filled with mud and rock to the depth of 1 to 4 feet in twenty minutes during a storm on the evening of August 6 last. The road is too narrow for teams to pass each other and there is constant danger of accident. One life has been lost here and one loaded coach overturned here last season. The road must be placed on the other side of the river. The construction will be difficult and costly. The road is the most used of any in the Park and its improvement as above outlined is an imperative necessity. The work has long been contemplated, but the money has never been available.

2. Golden Gate Canyon $15,000

Road through this canyon is mostly cut in side of cliff. For 200 feet it passes over wooden bridge. This bridge is about 15 years old and has reached its limit of safety. It will have to be condemned by the close of another season. The situation is such that an accident here would have appalling consequences. It is proposed to put in a series of concrete arches, covered with regular macadam roadway 16 feet wide, with a solid parapet 3 feet high. The cost will be in the neighborhood of $10,000.

The road through the canyon is in most places too narrow for teams to pass each other, and there are two short turns where the view ahead is abruptly and completely cut off. It is proposed to widen the road so that it shall everywhere be passable by two teams abreast, and to

make it much wider at the sharp curves. At the same time the steep grade will be eliminated and the whole made to conform to the grade and approaches of the new bridge. This will all be solid rock work and very costly—about $5,000 for the whole work.

3. Gibbon Canyon road $16,000

There still remains on this part of the road system about a mile of the original wagon trail not yet replaced by a good road. It includes two very steep hills, one of them with a sharp curve at the foot immediately on the bank of the river. The failure of brakes or any other mishap which might bring a team at the foot of the hill at high speed would inevitably precipitate the conveyance into the river. This stretch of road must be classed as dangerous.

The main road through the Gibbon Canyon is one of the most pleasing in the Park. It runs immediately along the bank of the river and is of easy grade. Unfortunately it is not built high enough above the river to make it safe. The river at every heavy flood goes clear over the road and has washed it out twice in the past six years. It is proposed to raise this road from 2 to 3 feet and make it safe against floods.

A road is needed to connect the Gibbon Canyon with the road down the Madison, to cut off a long detour for traffic going in that direction. The development of travel via the western approach has made this cut-off of great importance. This work involves the construction of a bridge over the Gibbon.

Of the three pieces of work in the Gibbon Canyon, the first two are of immediate and pressing urgency and the third is very desirable at an early date. The whole work has been estimated as equivalent to 8 miles of new road, at $2,000 per mile.

4. Roads near Fountain Hotel $8,000

These roads are already graded, but mostly with soft geyserite material, which forms an impassable quagmire in wet weather and is unendurable on account of suffocating dust in dry weather. A large part of this stretch of road is not now used, the coaches preferring the natural roads on the prairie. These roads should be thoroughly graveled. The work ought to be done at once. It is estimated to cost $1,000 per mile.

5. Snake River road $30,000

This road is merely grubbed and cleared, with trees and stumps left in middle of roadway most of the distance. The whole road is in a wretched condition and a disgrace to the Government. Travel from the south is rapidly increasing and the completion of the road is urgently needed. The above estimate is about $1,500 per mile, and will barely accomplish the work required.

6. Natural Bridge cut-off $16,000

This work is to replace about 12 miles of road around shore of lake by 8 across peninsula. A portion of the present road lies along the beach of the lake and has been so much injured by the lake that it is now abandoned. The remainder of the road lies back in the woods, out of reach of the lake, and is mostly built over uneven and sandy ground. It forms the most monotonous drive in the Park. The cut-off will reduce the distance 4 miles, cut out the ruined beach road, give

a better road, and pass directly by Natural Bridge, which can now be reached only by a separate drive. This work, though not of imperative necessity, is very important and should receive early consideration. Being all new work, it is estimated at the average cost of such work in the Park, $2,000 per mile.

7. Eastern approach, via Stinking Water River........................ $100,000

This item relates to the new approach from the east, extending from the east boundary of the forest reserve to the belt line in the outlet of the Yellowstone Lake. The construction of this road was authorized by act of Congress June 6, 1900. The distance is about 50 miles, and will cost not less than $2,000 per mile.

8. Yellowstone River road.. $15,000

This length of 15 miles is one of the best graded roads in the Park, carefully laid out by instrumental survey, and equal in this respect to any road in the world, but the material of which it is made is for the most part utterly worthless. The road becomes practicably impassable in wet weather and well nigh intolerable from dust in dry weather. It must be surfaced with rock or gravel. The work is urgently needed and should be done during the next season. It is estimated to cost $1,000 per mile.

9. New road on right bank of Grand Canyon........................ $6,000

This road is to give access to right bank of Grand Canyon for about 3 miles below the proposed bridge.

10. New road near Grand Canyon.................................... $5,000

The present road is one of the hardest to maintain in the Park. It has steep grades, is very narrow, and is held up by loose retaining walls, which are constantly caving in. A large part of these walls fell during the past winter. The material is also very bad and cuts all to pieces in wet weather. It is proposed to bridge Cascade Creek farther upstream and carry the road to the hotel at a higher level. This work will greatly relieve the task of maintenance in this vicinity.

11. Road from Norris to Grand Canyon.............................. $20,000

This road has three of the worst and most dangerous hills on the entire system. The Virginia Cascade hill is a positive menace to the lives of travelers. Several accidents have occurred here, and one life has been lost. Stage drivers are often compelled to make passengers alight and walk down the hill. The "Devil's Elbow," a very short turn of nearly 180°, is another dangerous place. Blandon Hill is a long, difficult, and dangerous ascent, which it is impossible to maintain in good condition. The long hill descending into the valley of the Yellowstone is composed of wretched material which so cuts up in wet weather as to be impossible of ascent by loaded wagons. The dense forests on top of the plateau retain the snow so late that it has to be shoveled out every spring at great expense. It is proposed to cut out some of the hills, reduce the grades on others, surface the bad stretches, and clear the timber away on the north side of the road so as to let the sun in. This work is of pressing importance, as the road will always be extensively used even after the Washburn road (see next item) is completed. It is estimated to cost as much as the entire relocation, or about $2,000 per mile for 10 miles.

12. The Mount Washburn road... $80,000

This is the only extensive portion of the Park road system that is still untraveled. Although it will be one of the most interesting and attractive parts of all, it has never been possible in a period of over twenty-five years to get money enough to undertake it. It is a great source of disappointment to all tourists that this section of the Park is shut out to them except on horseback. That portion of the road extending from near Baronett Bridge to Mammoth Hot Springs is a part of the road leading from Gardiner to Cooke City through the Park. As is well known, Cooke City has made a long and strenuous fight to get a railroad along this line, but the Government has wisely refused this privilege. In thus refusing, however, there is something of an obligation resting on the Government to provide at least a respectable highway for travel which has to follow this route, particularly as it does not permit private parties to build roads in the Park. The road, moreover, has long been a postal route from Mammoth Hot Springs to Cooke City. This road, therefore, is required for the double reason of forming a part of the regular tourist route and providing a necessary commercial highway across the Park. The present road is one of the most difficult and dangerous to be found in all the Rocky Mountains, and it is a discredit to the Government that travel over any part of the Park has to be made at this late day over such a thoroughly wretched highway. The entire work is of immediate and pressing importance. It is all new work and is estimated at $2,000 per mile.

13. Cooke City road $15,000

This connects with the main tourist route at the Yellowstone Bridge and extends to Cooke City. A part of the road in Soda Butte Canyon has been partly constructed, leaving upward of 15 miles to be built. This will have to be done when the new bridges are built, for the new road will not follow the old one, the bridge sites being differently situated. Remarks under item 12 apply to this road. It is of the greatest usefulness also in patrolling and protecting the entire northern portion of the Park, which is the most important game preserve on the reservation. Work much lighter than the average and is estimated at only $1,000 per mile.

14. Side roads and trails $9,000

The side roads lead to points of interest away from the main traveled roads. They are much less costly per mile to build on account of the smaller volume of travel passing over them and the less thorough construction required. There remain to be completed about 18 miles of these roads.

The trails play a most essential part in the protective work of the Park. They reach the localities remote from the tourist route and comprise several hundred miles. They are not maintained in as good condition as they used to be, for the reason that all the funds in recent years have gone into the roads. They require thorough clearing out and improving in the bad places.

15. Bridges $65,000

The bridges specified under this item are all large and important structures and can not well be undertaken under the usual small allowance for the Park without diverting the money from necessary work in other places.

Bridge over Yellowstone $10,000

This is to replace the old Baronett Bridge, which has now reached its limit of safety and will have to be condemned at an early date. It is even now unsafe for heavy loads. It is proposed to replace it with a permanent steel bridge on masonry abutments—span 100 feet. Cost estimated includes approaches. This work must be done during the next season or the bridge be abandoned. It is a very important crossing and is the site of the oldest bridge over the Yellowstone River.

Bridge over Yellowstone near Upper Falls $20,000

This work has long been of urgent importance. The public is still (twenty-seven years after creation of Park) entirely shut out from views on right bank of the Yellowstone. The superintendent has to send his patrols, for protecting the eastern part of the Park, via Baronett Bridge in extreme north of Park. The patrols at Grand Canyon and Yellowstone Lake can render no service in protecting the country on the east bank of the river. The bridge is thus a necessity both to the traveling public and for the proper police of the Park. Being in one of the grandest situations in the entire Park, its design and construction should conform to the surroundings. No cheap iron or wooden structure should be considered. It is proposed to adopt the construction known as the Melan arch, a combined steel and concrete structure in which great strength, artistic design, and reasonable cost can be combined. The whole structure has been worked out in detail, and with the approaches grading etc. will cost very close to the above sum.

Bridge over Yellowstone at lake outlet.................................. $10,000

This bridge is necessitated by Congressional action in directing construction of road described in item 7 above.

Bridge over Lamar River $5,000

A very important structure on road to Cooke City. Difficult to maintain unless a good bridge is built. Lamar River subject to greater floods than any other stream in the Park. Bridge at present site has washed out three times in past six years. Can not be held where it is. New location and new bridge immediately needed. Steel structure, with masonry abutments, proposed.

Bridge over Pelican Creek $3,000

This bridge is necessitated by Congressional action in directing construction of road described in item 7 above.

Bridges over Gibbon River.................................. $4,000

One of these bridges is to replace an old one, which is already broken, and must soon be abandoned. The other bridge is to connect the belt line with the western approach.

Bridges over Snake River on southern approach.................................. $6,000

These are quite large bridges, one over Lewis River, just below the lake, and the other over Crawfish Creek, near the point where it empties into the Snake River. The estimate (item 5) for completion of southern approach includes only grading and smaller bridges.

Bridge over Cascade Creek.................................. $5,000

This bridge will be a necessary part of the improvement at the Grand Canyon. It will be a high bridge, about 150 feet long.

Bridge over Nez Percé Creek.................................. $2,000

This stream has never yet had a bridge. In the season of low water it is perfectly fordable; but during the spring high water there ought to be a bridge.

16. New plant $5,000

This includes a portable rock-crushing outfit, a road roller, a steam derrick, concrete plant for bridge abutments, road machines, scrapers, plows, shovels, etc.

17. New office, etc $10,000

The Park work can not at present be said to have either office, storehouse, or quarters. The building used for an office is the flimsiest sort of a structure, through which dust, wet, and cold, according to the season, find their way with the greatest ease. The officer in charge and all the clerical force have only a single room some 15 feet square. The back of the building is used to store subsistence supplies. The building on right of office is a storehouse for tools—also a cheap structure. The building on left of office is the quarters for the office employees. In rear are several shacks and sheds, used for mess house, blacksmith shop, and storehouse.

There should be a small, well-built office building, and a large warehouse and mess house combined. This improvement is urgently needed, but it has never been possible to save enough money out of any appropriation to make it.

18. Repairs and maintenance $15,000

The average cost of maintaining the Park road system, based upon past experiences, is $100 per mile per year. There will be for the ensuing fiscal year about 150 miles on which no other work than maintenance will be done.

The foregoing estimate is for the completion of the existing project of improvement of the Yellowstone National Park. There is scarcely a possibility that additional roads will ever be required besides those included in this estimate. The figures given above are based upon the cost of regular continuous work, which shall be completed within a period of three years. If it drags along, as it must under an allowance of thirty to forty thousand a year, it will cost from one-third to one-half more than the above estimate and will not be completed under about twenty years. The estimate provides only for a first-class dirt wagon road, with good bridges. The macadamizing of the roads, which will come in time, and the cleaning away of brush, can be deferred for the present to be carried out under the annual provision for maintenance.

If Congress does not deem it advisable to provide for the systematic completion of this project under large appropriations, it should, if possible, make provision for the bridges under item 15, apart from the usual annual allowance. Some of these structures are now so old as to be a positive menace to the lives of travelers. In other places the lack of these bridges excludes the public absolutely from important features of interest. In still others it compels a resort to fording, which, in the months of June and July, is dangerous. The cost of these structures is too great to come out of the annual appropriations, if no larger than heretofore.

In the practical execution of the work in the park it would be of great advantage if the same system could be applied that obtains in river and harbor works, viz, that the appropriations could be immediately avail-

able upon the passage of the act and remain available until expended. The necessity of waiting to commence work under a new appropriation until the 1st of July and of expending it all before the 30th of June following, regardless of the needs of the work at the time, causes great inconvenience and a large loss of time every season.

PROTECTION.

The police duty of the park is a matter separate and distinct from the improvement work. The funds for the first purpose are disbursed by the acting superintendent; those for the second by an engineer officer. The appropriation for purposes so distinct and unlike should be separately provided for. In the case of the last two annual appropriations it has been necessary to make allotments for the two purposes, based upon a conference between the acting superintendent and the engineer officer. Such an arrangement is not a good one, and is liable to lead to difficulty and misunderstanding. It will be better for Congress to settle this matter itself and set apart what is intended to be devoted to protection. This amount has been in recent years about $5,000.

Statistics of business transacted in the Yellowstone National Park during the tourist season of 1899.

[The total number of tourists visiting the Park was very nearly 10,000, or, in exact figures, 9,772.]

Name of business concern.	Passenger miles or number of passengers hauled 1 mile.	Mile-tons or tons of freight hauled 1 mile.	Money value of business transacted.
Yellowstone Park Association		16,077	$120,000.00
Yellowstone Park Transportation Company	549,000	7,098	74,925.00
Monida and Yellowstone Park Stage Company	66,330	3,760	11,139.00
Wylie Camping Company	210,000	7,200	40,000.00
Yellowstone Lake Boat Company	77,650	31,500	40,000.00
Camping parties	852,890		
Miscellanous business		8,547	23,584.35
Quartermaster's Department		11,870	
Engineer Department		2,798	
Total	1,755,870	88,850	276,148.35

Money statement.

July 1, 1899, balance unexpended		$35,383.78
Amount appropriated by sundry civil act approved June 6, 1900 ($5,000 immediately available), less $5,000 allotted for protection		55,000.00
Amount transferred by Department of the Interior		248.61
		90,632.39
June 30, 1900, amount expended during fiscal year		33,902.17
July 1, 1900, balance unexpended		56,730.22
July 1, 1900, outstanding liabilities		5,458.71
July 1, 1900, balance available		51,271.51
Amount (estimated) for completion of existing project after work of current season, in which about $45,000 of appropriation will be expended in new work and $15,000 in repairs ($425,000 estimated cost of completion, less $45,000)		380,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1902:		
For works of improvement	$150,000.00	
For maintenance of improvement	15,000.00	
		165,000.00

Appropriations.

	Administration and protection.	Roads and bridges.	Total.
March 3, 1883	$16,429.97	$23,570.03	$40,000.00
July 7, 1884	16,999.98	23,000.02	40,000.00
March 3, 1885	16,790.63	23,209.37	40,000.00
July 15, 1886	934.25		934.25
August 4, 1886		20,000.00	20,000.00
March 3, 1887		20,000.00	20,000.00
October 2, 1888		25,000.00	25,000.00
March 2, 1889		50,000.00	50,000.00
August 30, 1890		75,000.00	75,000.00
March 3, 1891		75,000.00	75,000.00
August 5, 1892		45,000.00	45,000.00
March 3, 1893		30,000.00	30,000.00
August 18, 1894	10,565.24	89,434.76	30,000.00
March 2, 1895			30,000.00
June 8, 1896			5,000.00
June 11, 1896			35,000.00
June 4, 1897	6,736.74	28,263.26	35,000.00
July 7, 1898	11,356.57	28,643.43	40,000.00
March 3, 1899	5,534.64	34,465.36	40,000.00
June 6, 1900	5,000.00	55,000.00	60,000.00
Total	90,348.02	645,586.23	735,934.25

List of civilian engineers employed on works of improvement in Yellowstone National Park, Wyoming, from July 1, 1899, to June 30, 1900.

Name and residence.	Time employed.	Compensation per month.	Where employed.
	Months.		
C. E. Sherman, Columbus, Ohio	3	$150.00	Yellowstone National Park.
A. E. Burns, Mammoth Hot Springs, Wyo	3	125.00	Do.
S. F. Crecelius, Sioux City, Iowa	1	150.00	Do.

Appendix A.

REPORT OF MR. C. E. SHERMAN, ASSISTANT ENGINEER.

Columbus, Ohio, *September 30, 1899.*

Captain: I beg leave to submit the following report of work done in Yellowstone National Park during the past summer under my immediate supervision:

The main portion of my time was devoted to locating and superintending construction of a new road from Mammoth Hot Springs to the Golden Gate. In addition to this work, and carried on simultaneously with it as opportunity offered, I made detailed surveys of Glen Creek Canyon, Gardiner Canyon, Golden Gate Bridge, two sites for bridges over the Yellowstone above the Upper Falls, and a somewhat detailed examination of proposed road through Granite Canyon, on the Lamar River, about 8 miles east of Yanceys. I also made reconnaissances of a proposed road over Mount Washburn; of part of a road between Yanceys and Mammoth Hot Springs; of that part of same road lying between Yanceys and Granite Canyon, including bridge sites at the crossings of the Yellowstone and Lamar rivers, and of a proposed cut-off from Natural Bridge to the West Thumb of Yellowstone Lake. I also assisted in superintending construction of new bridge and approaches in the Gardiner Canyon

GOLDEN GATE ROAD.

This stretch of new road, completed the past summer, extends from a point on the old wagon road west of Observatory Hill to the same wagon road at a point 600 feet north of the east end of the Golden Gate Bridge, in all a length of 16,500 feet. Leaving the old wagon road near Observatory Hill, the new road winds around the foot of Jupiter Terrace of Mammoth Hot Springs, gaining the top by means of a loop upon the hillside, thus affording a fine view of the terrace from bottom to top; thence the the road curves around upon the hillsides at a continual upward grade to

the north entrance of the "Hoodoos," a point 4,600 feet north of Golden Gate. Through these immense rocks the road passes almost on a level for 1,800 feet. It then comes upon hillsides of trachitic rock, requiring tedious blasting, and gains the Golden Gate by a gradual ascent. There are no minus gradients in going from the Springs to the Golden Gate, excepting two slight indentations in the "Hoodoos," and the average grade is about 5½ or 6 per cent, nowhere exceeding 7, except a short stretch of between 8 and 9 per cent at the beginning and at the end of the new road. The general route had been selected by yourself, and it only remained for me to fix the details of the location instrumentally. Where the character of the country required the ground to be fitted closely, the method of "paper location" was used, in which a preliminary line is carefully run, side notes taken, from which a contour map is made, and from the "grade contour" on this map a line at a given gradient is fitted to the ground. The loop from the top to bottom of Jupiter Terrace was laid out by this method.

The material moved was of very varied character, and the broken condition of the country in places through which the line passed rendered it difficult to estimate accurately the quantities handled. Through the "Hoodoos" approximately 2,500 yards of loose and solid rock were moved. From the "Hoodoos" to the foot of Jupiter Terrace, roughly, about 15,000 cubic yards of loose rock, earth, and hardpan were excavated. The roadway was graded 18 feet wide and slightly crowned on the center. But three culverts were required, one of these being of stone and the other two of 20-inch cast-iron pipe, one being used at the foot of Jupiter Terrace to accommodate the flow of hot water from the large springs above.

GLEN CREEK CANYON.

This survey embraced that portion of the stage road extending from the Golden Gate Bridge to the bridge over Glen Creek, a distance of 2,000 feet. The road through this canyon is tortuous and steep in places, and the survey was made for the purpose of estimating the cost of remedying the two sharp and dangerous turns, cutting down the steep grades, and of widening the road throughout the pass. In connection with this survey a careful examination of Golden Gate Bridge was made, with a view to replacing this failing structure with one of a substantial construction.

GARDINER RIVER CANYON.

In this canyon the present road is in a precarious condition on account of slips from the cliffs on the east side of the river, and a survey was made for carrying the road on the west side until the dangerous part is passed. This survey extended from the bridge between mileposts 1 and 2 (from Gardiner) upstream 4,000 feet. During this survey stakes were also set for the concrete abutments of the new bridge replacing the old bridge mentioned above, and for the approaches on the north and south sides.

MOUNT WASHBURN ROAD.

Pursuant to instructions from you, during the latter part of August I made a reconnaissance of the proposed line for a road over Mount Washburn. Two routes have been proposed for a road from the Canyon Hotel to Yanceys, one lying on the eastern slope of the mountain, the other passing to the west of the main peak through the pass between it and Dunraven Peak. Both routes have been surveyed by Mr. T. Milton Fowble, assistant engineer, and you have map and profile of the eastern route. You will see by this profile that the line from the Canyon Hotel to Dunraven Pass has easy grades, it being possible, apparently, with but few exceptions, to secure a 6 per cent or less grade on this part of the line. Around the west side of Mount Washburn the line runs almost level, descending thence on the gently sloping northern side to Tower Creek.

My reconnaissance on the western route was to determine whether a road could be readily carried from Dunraven Pass to the summit, thence down on the north slope to join the main road. Accordingly I ran a line with tapeline and hand level from a stake near a large fir tree in the pass to the draw, 140 feet below the summit. The line thus run zigzagged up the mountain side, but it all lay upon favorable ground, free from snowdrifts, with little or no timber to clear away, and at no place exceeded a 10 per cent grade. This line measured 18,100 feet in length, not counting the 1,500 feet required to carry the road from station 181 to the extreme summit. To build it would require considerable blasting, as the soil in many places is not much over 6 inches deep upon the volcanic rocks of which the mountain is composed, and the

summit ledge would have to be cut through near the top. On the northerly slope I connected with Mr. Fowble's survey of 1895, at a point about 3 miles slightly west of north of the main peak, at an elevation of about 8,500 feet above sea level, where I planted a large stake in a pile of rocks. From this point to station 181 of the line from Dunraven Pass I ran a line on a 10 per cent grade or less with tape and hand level. This line measured 22,100 feet, and lay on favorable ground all the way, although to keep away from the timber and from snowdrifts it required a sinuous course. The soil and disintegrated rock on the north slope is considerably deeper than on the south slope, rendering construction easier on this part of the line. The whole line from Dunraven Pass to the summit and down again on the north slope to the junction with the main road, a total distance of about 8 miles, could be built single-track width, with convenient passing places, at about $2,000 per mile, and perhaps for less. Some provision against the high winds which prevail near the summit is, however, advisable. This branch road of 8 miles would make accessible the splendid panorama of the Park from the summit of Mount Washburn, and afford a fitting climax to the Park tour.

COOKE CITY ROAD.

The first part of this road examined lies about 4 miles east of Mammoth Hot Springs. At this place the roadway runs along the mountain side south of the East Gardiner River, and is excavated through a crust of black earth some 3 or 4 feet thick into a gravelly subsoil. This crust is continually breaking off and slipping down upon the road, carrying trees and rocks with it, and keeping the road in constant danger. From an examination of the vicinity it appears that this road could be carried around on a partial shelf in the rocks about 100 feet below and to the north of its present position, thus avoiding all danger from slips and cutting out a stretch of 12 per cent grade in the present road. The road could be built on this latter line at probably the cost of the present location, and would certainly be cheaper to maintain. Some special construction would be needed on the new line at points where the shelf is broken.

No further examination of this road was made until Yanceys was reached. Two miles beyond Yanceys the Yellowstone is crossed on Baronett Bridge. Before and after this crossing the road is steep and rocky and in bad condition, and the bridge is worse, being now positively dangerous for heavily loaded wagons. The site selected by you for a new bridge is upstream about one-third of a mile from Baronett Bridge, and I made a careful examination of this site and its approaches for about 1 mile on either side with tape and hand level, triangulating the width of the stream, which is 100 feet at this point. The grades on neither side will exceed a 7 per cent, except possibly a short stretch at the east approach, and on the east side of the river, where the proposed road passes to the south of Junction Butte (the present road lies on the north side), the grade will average very much less than 7 per cent, and construction will be cheap.

From Junction Butte east to Granite Canyon the proposed line has very easy grades and can be economically constructed, as much of the line, being prairie, is passable now. Between Junction Butte and Grand Canyon are several feasible sites for a bridge across the Lamar River, but that at the ford, about a mile above the mouth of Slough Creek, appears to offer most advantages. A span of 100, possibly 125, feet would be required, and the approaches for short distances on either side would need riprapping. After reaching the top of the table-land on the north side of the river, the prairie is almost as level as a floor until we reach

GRANITE CANYON.

Through this gorge the river flows for a mile between two walls of pure gray granite, while the bed of the stream is filled with huge bowlders of the same material, worn smooth and slippery by the action of the water. The north wall, however, is back quite a distance from the stream, and the space between wall and river is occupied by earth and bowlders sloping down to the water's edge. Along this sloping ground I ran a line from end to end, 6,000 feet in length, with tape, hand level, and prismatic compass, and found that a road with gradients averaging about 5 per cent and not exceeding 7 per cent can be constructed at a cost not exceeding $2,000 per mile, except at the upper end, where for a distance of 300 feet the road must be blasted into the side of a sloping granite wall overhanging the river. A road through this canyon would replace the steep and difficult stretch south of it, and at the same time afford a most charming bit of scenery.

NATURAL BRIDGE CUT-OFF.

The reconnaissance of the line from Natural Bridge to the West Thumb was made in company with yourself, and was for the purpose of ascertaining whether any serious obstacle existed to building the proposed cut-off over the route examined. The route was found to be perfectly feasible, and if the road is built it will save about 3½ miles of tedious staging, besides carrying the tourist past one of the natural curiosities of the park, which can now be seen only by a special side trip.

The drawings[1] accompanying this report were made in Columbus after my return from the park, and are: Stadia map of west bridge site over the Yellowstone; sketch map and profile of site above Baronett Bridge; map and profile of line through Granite Canyon; profile of western route over Mount Washburn; map of the Glen Creek Canyon; map of new Golden Gate road; profile of same; map and profile of Golden Gate Bridge; map of the Gardiner Canyon.

Very respectfully, your obedient servant,

C. E. SHERMAN,
Assistant Engineer.

Capt. H. M. CHITTENDEN,
Corps of Engineers, U. S. A.

APPENDIX B.

REPORT OF MR. A. E. BURNS, OVERSEER.

UNITED STATES ENGINEER OFFICE,
Sioux City, Iowa, March 1, 1900.

SIR: I have the honor to submit herewith a general résumé of operations pertaining to the improvement of Yellowstone National Park, covering a period from date of the act of dedication, March 1, 1872, to the close of the fiscal year ending June 30, 1900.

By act of Congress dated March 1, 1872, the Yellowstone National Park was set apart from the public domain and placed in the charge of the Government and under the direction of the Secretary of the Interior.

On May 10, 1872, the Secretary appointed N. P. Langford as the first superintendent of the Park. He was removed on April 18, 1877, and no money was appropriated for improvements during the time he held office.

A rough wagon trail was opened by Gen. O. O. Howard when passing through a portion of the Park in pursuit of the Nez Perce Indians in 1877, from the west boundary through the Madison Canyon and over Marys Mountain to the Yellowstone Falls, and a similar trail had been constructed some time prior to this date by private enterprise from the north boundary of the Park via Blacktail Creek, the Lamar River and Soda Butte Creek to the northeast corner. Marked on accompanying map.

On April 18, 1877, P. W. Norris was appointed superintendent, and on June 20, 1878, Congress made the first appropriation, $10,000, "To protect, preserve, and improve the Park."

A wagon trail was opened from Mammoth Hot Springs via Snow Pass, Beaver Lake, Norris, and the Gibbon River to a junction with Howard's road at a point near the Lower Geyser Basin, about 40 miles, and from thence to the Upper Geyser Basin, about 14 miles. Roads marked on accompanying map.

Work accomplished, 1878.

Rough wagon trails .... miles..	54

Money statement, 1878.

Appropriated	$10,000.00
Expended, construction and maintenance of roads and bridges and administration and protection	10,000.00

On March 3, 1879, an appropriation was made of $10,000, with which amount the following improvements were accomplished:

Wagon trails were constructed from the Mammoth Hot Springs to the north boundary, 6 miles; Mammoth Hot Springs to the East Gardiner, 2 miles; Mammoth

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[1] Not printed.

Hot Springs to the West Gardiner, 2 miles; from the junction with Howard's road, near Lower Geyser Basin, to Riverside, 13 miles; Forks of the Firehole to Cold Springs Creek, 7 miles. Roads marked on accompanying map.

Work accomplished, 1879.

Rough wagon trails.....miles.. 30

General repairs to all trails.

Money statement, 1879.

Appropriated	$10,000.00
Expended, construction and maintenance of roads and bridges, and administration and protection	10,000.00

Summary of work from June 20, 1878.

Wagon trails constructed.....miles.. 84

Money statement.

Appropriated June 20, 1878, to March 3, 1879	$20,000.00
Expended	20,000.00

On June 16, 1880, $15,000 was appropriated, and was expended as follows:

One mile of road was opened between Mammoth Hot Springs and the East Gardiner, and from Lower Geyser Basin to Riverside 18 miles was opened. Roads marked on accompanying map.

Work accomplished, 1880.

Rough wagon trails.....miles.. 19

General repairs to all trails.

Money statement, 1880.

Appropriated	$15,000.00
Expended, construction and maintenance of roads and bridges, and administration and protection	15,000.00

Summary of work from June 20, 1878.

Wagon trails constructed.....miles.. 103

Money statement.

Appropriated June 20, 1878, to June 16, 1880	$35,000.00
Expended	35,000.00

On March 3, 1881, $15,089.76 was appropriated, and was expended as follows:

A road was opened from the Forks of the Firehole to Yellowstone Lake, 30 miles, from the above road to Alum Creek, 4 miles, and from the East Gardiner River to Tower Falls, 20 miles. Roads marked on accompanying map.

Work accomplished, 1881.

Rough wagon trails.....miles.. 54

General repairs to all trails.

Money statement, 1881.

Appropriated	$15,089.76
Expended, construction and maintenance of roads and bridges, and administration and protection	15,089.76

Summary of work from June 20, 1878.

Wagon trails constructed.....miles.. 157

Money statement.

Appropriated June 20, 1878, to March 3, 1881	$50,089.76
Expended	50,089.76

On February 2, 1882, P. H. Conger succeeded P. W. Norris as superintendent.

On August 5 and August 7, 1882, $18,335.41 was appropriated, and was expended as follows:

A road was built from Alum Creek to the Yellowstone Falls, 3 miles. Road marked on accompanying map.

Work accomplished, 1882.

Rough wagon trails .... miles..	3
General repairs to all trails.	

Money statement, 1882.

Appropriated	$18,335.41
Expended, construction and maintenance of roads and bridges, and administration and protection	18,335.41

Summary of work from June 20, 1878.

Wagon trails constructed .... miles..	160

Money statement.

Appropriated June 20, 1878, to August 7, 1882	$68,425.17
Expended	68,425.17

To this date (close of season, 1882) the appropriations had been disbursed by the civilian superintendents, under the direction of the Secretary of the Interior, principally for administration, and the amounts available for the construction of roads and bridges were used to open such rough trails to the various points of interest as the very limited means allowed. This work was necessarily of a primitive character, and counted nothing whatever toward the work executed later when larger appropriations and systematic methods made permanent improvements possible. The whole of the roads built at this time have since been abandoned, excepting portions of the road to the east boundary, and are not included in the following statement, which covers the expenditure since the date when the work of improvement was first placed under the direction of the Secretary of War.

In July, 1883, Capt. D. C. Kingman, Corps of Engineers, was placed in charge, and on this date commenced the actual systematic series of improvements, and the first expenditure which can properly be charged to the undertaking.

After a careful study of the situation Captain Kingman submitted the following project, which, with a few alterations, has been adhered to in all subsequent operations:

Project.—The construction and general maintenance of a system of roads as follows:

	Miles.
From the north boundary of the Park to Mammoth Hot Springs	5
From Mammoth Hot Springs to Lower Geyser Basin	40
From Lower Geyser Basin to the Upper Geyser Basin	10
From Lower Geyser Basin to the Grand Canyon	28
A branch of this road to the outlet of the Yellowstone Lake	8
From Mammoth Hot Springs to Yanceys	18
From the Grand Canyon over Mount Washburn to Yanceys	20
From the Upper Geyser Basin to the outlet of Yellowstone Lake	40
From Norris Geyser Basin to the Grand Canyon	9
From Lower Geyser Basin to the west boundary of the Park via the Madison Canyon	20
From Yanceys to the east boundary of the Park via Soda Butte	35
In all, about	233

On March 3, 1883, Congress appropriated $40,000 for all purposes pertaining to the Park improvement and protection. Of this amount $23,570.03 was made available for construction and repairs of roads and bridges.

On July 7, 1884, an appropriation of $40,000 was made, of which $23,000.02 was available for the construction and repairs of roads and bridges; and a further appropriation of March 3, 1885, of $40,000 allowed $23,209.37 to be used for the same purpose. On July 15, 1886, $934.25 was appropriated and expended for compensation of the superintendent and employees. On August 4, 1886, an appropriation was

made for improvements only, to be expended under the direction of the Secretary of War, amount $20,000.

Total amount appropriated from March 3, 1883, to August 4, 1886, $140,934.25.

A road was constructed from the north boundary of the Park, near Gardiner, to the Mammoth Hot Springs via the Gardiner River Canyon; 5 miles entirely new road; cost $7,750.52, including a three-span crib-pier bridge, rough logs 88 feet by 14 feet 4 inches, and a three-span King truss bridge, hewn logs 106 feet by 14 feet 4 inches; (1884-85). Two miles of the road and both bridges are now abandoned.

A road from Mammoth Hot Springs through the Golden Gate to Swan Lake Flats, 5 miles of entirely new road, cost $14,395.39, including a half-bent trestle of rough logs anchored into cliff, 224 feet by 14 feet 4 inches; cost, $3 per running foot (1883–1885). Three miles of road abandoned in 1899. Trestle and road through canyon to be abandoned in 1900.

A road from the south end of Beaver Lake to Norris Geyser Basin, 7 miles, 6¼ miles all new road, three-fourths mile old road rebuilt; cost, $6,269.80 (1885). Three miles since abandoned. Four miles in present use.

From Lower Geyser Basin to Upper Geyser Basin, 9 miles, all new road; cost $6,042.52, including a two-span King truss bridge, hewn lumber, 70 feet by 14 feet 4 inches; a trestle bridge on seven bents 112 feet by 14 feet 4 inches; and a three-span crib-pier bridge, rough logs 75 feet by 14 feet 4 inches (1885). About 4 miles abandoned as part of the regular circuit. Remainder of road still in use. Pier bridges both pulled down and rebuilt.

In Gibbon Canyon, 3 miles, all new road; cost $4,604.60, including a Queen truss bridge, hewn timber, 84 feet by 14 feet 4 inches (1884-85). Road still in use; bridge unsafe.

Along Yellowstone River, near the Grand Canyon, 1½ miles new road; cost $1,919.57 (1884). All abandoned.

The project summitted and approved for the expenditure of the appropriation of August 4, 1886, was as follows:

To build a wagon road from Norris to the Grand Canyon, 12 miles, to cost $12,000. General repairs to existing roads, $8,000.

The following was accomplished:

About 9.5 miles of the Norris Canyon road was opened in a rough manner; cost, $9,368.48 (1886). About 2 miles now abandoned as part of the regular circuit. Remainder of road still in use, but requires extensive alterations and relocating in some places.

Rebuilding of old road along Beaver Lake and Obsidian Cliff; cost $4,431.49, including a King truss bridge, 30 feet by 14 feet 4 inches, sawed lumber (1886). Road and bridge still in use. Bridge needs repairing. These roads are marked on accompanying map:

New work accomplished, 1883 to 1886, including 20 bridges..............miles.. 42

Wagon trails abandoned, 34.5 miles, Norris and Conger.

Money statements, 1883 to 1886.

Appropriated		$140, 934. 25
Expended, new work	$69, 396. 34	
Completion and maintenance	20, 383. 08	
Administration and protection	51, 154. 83	
		140, 934. 25
Cost of construction per mile		1, 652. 00

Captain Kingman's estimate at this time for the completion of the original project was $250,000 and for the following season's work (fiscal year ending June 30, 1888) as follows:

Road from Upper Geyser Basin to outlet of Yellowstone Lake via the West Arm	$40, 000
Road from Lake Outlet to Yanceys via the Grand Canyon	45, 000
Road from Yanceys to Mammoth Hot Springs	20, 000
Road from Lower Geyser Basin to west boundary of Park	20, 000
For general repair and improvement of existing road	25, 000
	150, 000

In the above estimate he omitted the roads from Yanceys to the east boundary via Soda Butte, 35 miles, and from Lower Geyser Basin to the Grand Canyon via Marys Mountain, 28 miles; total, 63 miles.

The original project submitted by Captain Kingman in 1883 provided for 233 miles.

	Miles.
New roads constructed, 1883, 1884, 1885, 1886	42
Old roads rebuilt or repaired	28
Proposed to be built in 1887, per estimate submitted	100
Temporarily dropped from project	63
Total	233

For the 100 miles to be built the following season he estimated the cost at $125,000 and necessary repairs $25,000.

Experience has since proved that this estimate was altogether too low, as will be shown in the later reports.

Captain Kingman's original estimate placed the cost of building such roads as he judged were needed at $1,000 per mile, and the proper maintenance of same after completion at $100 per mile.

At the end of the working season of 1883 he estimated that $205,000 would then be required to complete the project.

On March 3, 1887, an appropriation of $20,000 was made under like conditions as the preceding one, to be available July 1, 1887.

On April 1, 1887, Capt. C. B. Sears was appointed to succeed Captain Kingman. He arrived in the Park in May, 1887, and with an unexpended balance of $3,547.58, received by him from Captain Kingman, he executed necessary spring repairs to open the road for the summer travel. This amount is included in the report of general repairs already stated for the fiscal year ending June 30, 1887.

Captain Sears submitted the following project for the disbursement of the appropriation:

To finish the present incompleted road from Norris to the Grand Canyon, about 12 miles.

New road from Swan Lake Meadows to Beaver Lake, about 7 miles.

New road from Norris Geyser Basin to the Gibbon Canyon, about 6 miles.

New road from Gibbon Canyon to Lower Geyser Basin, about 10 miles, or as much thereof as the remaining funds will permit.

The work accomplished was as follows:

Improvements on the stretch of incompleted road between Norris and the Grand Canyon, equivalent to about 4 miles of new road (1887); in use to present date.

New road from Swan Lake Meadows to Beaver Lake, 6 miles (1887); in use to present date.

New road from Norris Geyser Basin to the Gibbon Canyon, 4 miles (1887). Two miles abandoned; balance in use to present date.

A bridle trail from near Cascade Creek to the Lower Falls (1887). Still in use.

Above work shown on accompanying map.

New work accomplished, 1887, including 1 bridge .... miles.. 14

Wagon trails abandoned, 10.5 miles, Norris.
Wagon roads abandoned, 2 miles, Kingman.

Money statement, 1887.

Appropriated		$20,000
Expended, new work	$14,905.94	
Completion and maintenance	5,094.06	
		20,000
Cost of construction per mile		1,064

Summary of work fvom March 3, 1883.

	Miles.
Roads constructed, including 21 bridges	56
Total mileage abandoned:	
Wagon trails	45
Roads	2

Money statement.

Appropriated March 3, 1883, to March 3, 1887		$160,934.25
Expended, new work	$84,302.28	
Completion and maintenance	25,477.14	
Administration and protection	51,154.83	
		160,934.25
Total cost of construction to this date per mile		1,505.00

Captain Sears renewed the estimate for $150,000 made by Captain Kingman, less the $20,000 appropriated, making $130,000, the sum asked for by him for the fiscal year ending June 30, 1889, with which sum he proposed to accomplish the following:

To build a road from Upper Geyser Basin over the Continental Divide to the outlet of the Yellowstone Lake via the West Arm, 30 miles	$40,000
To improve and complete the present rough road from the lake to Grand Canyon, 14 miles	10,000
To build a new road from the Grand Canyon to Yanceys, 20 miles	30,000
To improve and complete the present rough road from Yanceys to Mammoth Hot Springs, 18 miles	20,000
For general repairs of existing roads	20,000
For sawmill and rock crusher	5,000
For offices and dwelling	5,000
	130,000
Amount estimated for completion of existing project	250,000

On April 16, 1888, Maj. C. J. Allen relieved Captain Sears, and during the early spring expended the $835.22 turned over to him by his predecessor on general repairs.

Lieut. W. E. Craighill was detailed to assume local charge under Major Allen.

On October 2, 1888, Congress made an appropriation of $25,000. It was too late for any work to be done that season, but during the ensuing spring, which was unusually early, the following was accomplished toward the project as outlined by Captain Sears:

New road near Mammoth Hot Springs on road to north boundary, about 1.5miles. Used to present time.

New road near Swan Lake, about 1 mile. Used to present time.

Bridge over Gardiner River (Indian Creek), 40-foot truss and 20-foot trestle approach. Used to present time.

Commencement of a road down Gibbon Canyon, about one-half mile. Still used.

Finishing road from Norris Geyser Basin to Grand Canyon, about 1 mile. Used to present time.

Trestle at junction of roads to Grand Canyon and Yellowstone Lake, 115 feet by 14 feet 4 inches. Used to present time.

Bridge over Cascade Creek near falls, 40-foot truss, 30-foot trestle approach. Used to present time.

Trestle over Gibbon River in Gibbon Canyon, about 1¾ miles above the falls, 86 feet by 14 feet. Used to present date.

Much repair work was found necessary in consequence of none having been done the previous summer through the lateness of the appropriation.

The wagon trail through the Madison Canyon to Riverside was made passable; abandoned in 1896.

Roads built marked on accompanying map.

A Brownell's pony sawmill and a Nagle portable engine, 12 horsepower, were purchased; cost, $1,267.82.

New work acomplished, 1888, including 4 bridges .... miles.. 4

Wagon trails abandoned, 1 mile, Norris.

Roads abandoned, 1.5 miles, Kingman.

Money statement, 1888.

Appropriated		$25,000.00
Expended, new work	$10,000.00	
Completion and maintenance	15,000.00	
		25,000.00
Cost of construction per mile		2,500.00

Summary of work from March 3, 1883.

	Miles.
Roads constructed, including 25 bridges	60
Total mileage abandoned:	
Wagon trails	46
Roads	3.5

Money statement.

Appropriated March 3, 1883, to October 2, 1888		$185,934.25
Expended, new work	$94,302.28	
Completion and maintenance	40,477.14	
Administration and protection	51,154.83	
		185,934.25
Total cost of construction to this date, per mile		1,571.00
Amount estimated still required for completion of existing project		230,000.00
Estimate for the ensuing season, fiscal year ending June 30, 1890		130,000.00

Project for expending the same was as follows:

To complete the belt line by building a road from the Upper Geyser Basin to the outlet of the Yellowstone Lake via Shoshone Lake; thence along the Yellowstone River to the Grand Canyon; thence to the Mammoth Hot Springs via Mount Washburn and Yanceys.

To repair and complete the roads already built or commenced under the present project.

To construct and repair such crossroads and bridle paths as may be necessary, and in purchasing the plant and erecting the buildings needed for the work.

Major Allen recommended that the roads be protected by parapets wherever they are built close to precipices of water, and at many points increased to a width of 24 feet. He also advocated the purchase of a portable rock crusher.

On March 2, 1889, Congress made an appropriation of $50,000, with part of which sum Major Allen proposed to open the road as described in his estimate from Upper Geyser Basin to the Grand Canyon via Shoshone Lake and Yellowstone Lake. He estimated the distance at about 57 miles.

He also proposed to extend the Gibbon River road about 2½ miles and have a sufficient balance for repairs and contingencies.

The probable cost of the work necessary to complete the project, the maintenance of same, repairing of old roads, erection of warehouse and office, dwelling house for overseer, purchase of rock crusher and general tools, and contingencies, he estimated at $260,000, or about $2,000 per mile for new roads. This was just double the amount of Captain Kingman's estimate, and was still too low to construct the class of road needed in the Park, as demonstrated by subsequent examples.

Major Allen strongly urged the necessity of a thorough survey being made, from which to project an engineer road map. He estimated the entire cost of same, including explorations, locations for future roads, and measuring roads already built, at $25,000, and asked for an appropriation for that purpose.

Maj. W. A. Jones succeeded Major Allen, Lieut. W. E. Craighill in local charge. With the $50,000 appropriated March 2, 1889, operations were commenced on July 1, 1889.

The proposed road from Upper Geyser Basin to the Grand Canyon, to complete the projected belt line, was started by the building of a road from the Yellowstone Lake outlet toward the West Thumb, 7.4 miles, including 2 trestles 90 by 14 feet, 2 trestles 30 by 14 feet, 7 trestles 15 by 14 feet; cost, $1,627.14 per mile. It was estimated at this time that a further expenditure of $500 per mile would be necessary to complete it. Road not yet completed, but used to present time.

The road was also started from the west end by building from the Upper Geyser Basin toward the West Thumb of the Yellowstone Lake along the Firehole River, 3.5 miles. The cost and amount necessary to complete it was the same as the Lake Shore road, first described. Road not yet completed, but used to present date.

One and one-tenth miles road in Gibbon Canyon to join partly constructed road to old road near mouth of Canyon Creek; cost, $4,073.70 per mile, including heavy rock-work and high retaining walls; used to present time.

One thousand six hundred feet of road around Brickyard Hill; cost, at rate of $2,218.06 per mile; used to present time.

Six thousand seven hundred feet on Swan Lake Meadows; cost, $921 per mile; used until present time.

The new road from Norris to the Grand Canyon was improved by an addition of 6,200 feet near Canyon Hotel, including 3,700 cubic yards of rock in a retaining wall; cost, per mile, $8,365.66; used to present time. New work equal to about 9 miles new road.

Marked on accompanying map.

New work accomplished in 1889, including 11 bridges .... miles.. 9

Wagon trails abandoned, 3 miles, Norris.

Roads abandoned, 3 miles, Kingman.

Money statement, 1889.

Appropriated		$50,000.00
Expended, new work	$42,000.00	
Completion and maintenance	8,000.00	
		50,000.00
Cost of construction per mile		4,666.00

Summary of work from March 3, 1883.

	Miles.
Roads constructed, including 36 bridges	69
Total mileage abandoned:	
Wagon trails	49
Roads	3.8

Money statement.

Appropriated March 3, 1883, to March 2, 1889		$235,934.25
Expended, new work	$136,302.28	
Completion and maintenance	48,477.14	
Administration and protection	51,154.83	
		235,934.25
Total cost of construction to this date, per mile		1,975.00
Amount (estimated) still required for completion of existing project		260,000.00

With the object of deciding on the best point of entry to the Park from the south, Lieutenant Craighill made a reconnaissance in August. He reported the most feasible route to be from a point where the Snake River crosses the southern boundary up Snake River and Lewis River to the West Thumb of Yellowstone Lake via Lewis Lake and Shoshone Lake.

On August 30, 1890, Congress made an appropriation of $75,000. The late day at which this amount became available made it impossible to commence any operations for that season beyond making a survey for the road which it was proposed should be built from the Upper Basin to the Yellowstone Canyon and the execution of necessary repairs.

A survey was made under the personal supervision of Lieutenant Craighill by which a line was located and the necessary measurements taken for quantities for a road between the points designated; distance, 64 miles. The route chosen was from the Old Faithful Geyser up the Firehole River to the mouth of Spring Creek, up Spring Creek to the summit of the Continental Divide, crossing the divide at Grants Pass, and down Shoshone Creek to Shoshone Lake, around the western and northern shore of the lake, and recrossing the Continental Divide, to the west arm of the Yellowstone Lake, along the lake shore to its outlet and down the Yellowstone River to the Grand Canyon. Cost of survey, $2,700. About 55 miles of road was extensively repaired, and the notes of the survey were worked up during the winter; cost, $19,144.40. Proposals were invited for constructing the road by contract, and awards were made for 27.8 miles to be built.

A further appropriation of $75,000 was made on March 3, 1891, to which amount was to be added the unexpended balance of the previous year's appropriation, viz, $53,155.60.

In the spring of 1891 Lieut. H. M. Chittenden succeeded Lieutenant Craighill in local charge.

The act of March 3, 1891, provided that a road should be built by the shortest practicable route from Fountain Geyser to the West Thumb of Yellowstone Lake, thus changing the route of the belt line as set forth in the original approved project, and abandoning the proposed road around Shoshone Lake, a location for which had been surveyed in 1890. Examinations of the country between Fountain Geyser and the Yellowstone Lake were made by Major Jones and Mr. E. Lamartine, overseer, but no practical route was found for a road. Reconnaissances and preliminary surveys were made by Lieutenant Chittenden, and a location proposed by him was decided on for a road from the mouth of Spring Creek, crossing the Continental Divide twice, to the West Thumb of the Yellowstone Lake. During the spring of 1891 the first experiments were made with section crews. Three parties were placed on given sections and one party with a road-leveling machine traveled over the entire road system.

Of the new work, one section only was done under contract, about 7.5 miles, from near the Mud Geyser to the rapids above the Upper Falls of the Yellowstone. The remainder was all done by day-labor.

A road was constructed from a point 3.5 miles above the Upper Geyser Basin to the Grand Canyon of the Yellowstone. The line decided on ran from the Firehole River up Spring Creek, crossed the Continental Divide at Craig Pass, descended into the Shoshone Valley; crossed De Lacey Creek, crossed the Continental Divide again, and descended to the shore of the Yellowstone Lake at the West Thumb. It then followed the lake shore to the Outlet, from which point it followed the general course of the Yellowstone River to the Grand Canyon. Twenty large bridges were built on this road and many small ones. Distance, 36.1 miles entirely new road, and 2 miles of old road rebuilt. Cost, $106,939.03, or $2,959.84 per mile for construction only. Unfinished portions of this road were subsequently completed and considerable repair work done on some parts of it. The greater portion has needed no repairs whatever. The whole length of the road has been used constantly to present date.

A piece of road was built from near the ford on Nez Perce Creek to the Fountain Hotel; length, 1 mile; cost, $3,839.52. Used to present date.

A topographical survey was made covering almost the entire road circuit. The work was afterwards platted and is the only authentic road map of the Park yet made; cost, $2,280.12.

About 410,000 feet of lumber was sawed, at a cost of $8,209.53—$20.02 per thousand.

About 67 miles of road was kept in good repair, at a cost of $3,594.

Office and contingencies, $3,293.40.

Roads marked on accompanying map.

New work accomplished, 1890 and 1891, including 20 bridges ....miles..	47.5

Wagon trails abandoned, 36 miles, Norris.

Money statement, 1890 and 1891.

Appropriated		$150,000.00
Expended, new work	$135,645.30	
Completion and maintenance	4,354.70	
Surveys	10,000.00	
		150,000.00
Cost of construction per mile		2,855.00

Summary of work from March 3, 1883.

	Miles.
Roads constructed, including 56 bridges	116.5
Total mileage abandoned:	
Wagon trail	85
Roads	3.8

Money statement.

Appropriated March 3, 1883, to March 3, 1891		$385,934.25
Expended, new work	$271,947.58	
Completion and maintenance	52,831.84	
Surveys	10,000.00	
Administration and protection	51,154.83	
		385,934.25
Total cost of construction to this date per mile		2,334.00

A small steam launch was obtained from the Government reservoirs at the headwaters of the Mississippi River. This was shipped by rail to Cinnabar, Mont., from which point it was hauled by teams to the Yellowstone River above the larger rapids. It was then placed in the water and steamed to the Yellowstone Lake, where it was put to most valuable use in assisting the crews engaged in building the new road along the lake shore.

A careful study of the existing conditions throughout the entire area where roads have been constructed and a comparison of the results with the amount of money expended to that date, aided by an accurate account which had been kept of the cost of all operations during the expenditure of the last two appropriations, led Lieutenant Chittenden to believe that roads built to comply with the needs of the Park could not be constructed for less than $4,000 per mile, and that an extra expenditure of $1,000 per mile would be required to make the roads already reported as built conform to the specifications. He also recommended that the right of way for all roads be cleared 50 feet in width; that no new work of any kind be undertaken without a thorough survey and a close examination of the adjacent country being first made, and that the whole of the work of improvement undertaken in the

Park should conform to a standard of excellence equal to the best roads in this country or in Europe.

He also suggested that steps be taken to secure the astronomical determination by the United States Coast and Geodetic Survey of the position of some convenient point within the limits of the Park.

An appropriation of $45,000 was made on August 5, 1892. The previous year's appropriation was all exhausted on June 30, and no work was done after that date. The act provided "that $15,000 of the amount, or so much as may be necessary, may be expended, in the discretion of the Secretary of War, for the construction of a road from the Upper Geyser Basin to a point on Snake River where it crosses the southern boundary of the Park." The project previously submitted for expending the remaining $30,000 was approved, and a separate project for expending the $15,000 was approved later. The working forces were organized and operations commenced as soon as the money became available. A branch road was built around the terraces at the Mammoth Hot Springs; cost, $449.06; used to present date. A road along the rapids of the Yellowstone River near the Upper Falls; about 1 mile partly completed; cost, $1,807.43; used to present date. A road from the old wagon road to Inspiration Point; about one-half mile; cost, $323.41; used to present date. Road around the Norris Hill, 1¾ miles, including a 30-foot span King truss bridge; cost, $4,638.18; used to present date. Commencement of new road down the Gibbon River to the Fountain Geyser Basin, including a 48-foot crib pier bridge; cost, $4,142.44; used to present date. Commencement of new road from Fountain Geyser toward Upper Basin; one-half mile near Excelsior; cost, $473.53; used to present date.

New road constructed, or partly constructed, equal to about 6 miles; total cost, $11,834.05.

Rebuilding short sections and general repairs on road from Mammoth Hot Springs to the east boundary, including a three-span crib pier bridge over the Lamar River and several small bridges; cost, $1,708.11; bridge destroyed by floods during spring of 1893.

General repairs and road completion on sections of road built in 1891 from Upper Geyser Basin to the Grand Canyon, via the West Thumb and Lake Outlet, including one 35-foot Queen truss bridge, one 57-foot double King truss bridge, one 29-foot King truss bridge, and one single-span bridge; cost, $12,474.70.

General repairs and graveling various portions of road circuit; cost, $5,823.27.

Rock foundation for wooden arch bridge near the rapids of the Yellowstone; cost, $281.43.

Finishing general survey of road system; cost, $1,096.14.

Mileage, St. Paul office, and expenses during winter and spring of 1893; cost, $6,543.20.

A contract was let for opening a road from the West Thumb of the Yellowstone Lake toward the south boundary of the Park in accordance with the provisions of the act of Congress of August 5, 1892.

Roads built marked on accompanying map.

New work accomplished 1892, includiug 7 bridges ....miles.. 6

Wagon trails abandoned, 2 miles, Norris.

Roads abandoned, 2 miles, Kingman.

Money statement, 1892.

Appropriated		$45,000.00
Expended, new work	$14,215.48	
Completion and maintenance	23,606.08	
Surveys	1,239.34	
		39,060.90
Amount covered by uncompleted contract		5,939.10
Cost of construction per mile		2,369.00

Summary of work from March 3, 1883.

	Miles.
Roads constructed, including 63 bridges	122.5
Total mileage abandoned:	
Wagon trail	87
Roads	5.8

Money statement.

Appropriated March 3, 1883, to August 5, 1892		$430,934.25
Expended, new work	$286,163.06	
Completion and maintenance	76,437.92	
Surveys	11,239.34	
Administration and protection	51,154.83	
		424,995.15
Amount covered by uncompleted contract		5,939.10
		430,934.25
Total cost of constructing road to this date per mile		2,336.00

The revised project provided for about 245 miles of road, including an approach from each side of the square occupied by the Park; also about 50 miles of branch roads to objects of interest not on the main belt road; total, 295 miles. Of this distance 125.3 miles had been built, leaving 169.7 to be constructed. Major Jones estimated that $395,100 would be required for the completion of the work, and an additional sum of $200 per mile for the maintenance of same after construction.

An appropriation of $30,000 was made on March 3, 1893.

Lieut. H. M. Chittenden was transferred and the work was carried on under the direction of Maj. W. A. Jones, assisted by Charles A. Hunt, United States overseer, in local charge.

A road to the south boundary was commenced by the grubbing and clearing of a right of way from the belt line near the West Thumb of the Yellowstone Lake toward a point near Snake River on the south boundary. Twelve and one-half miles was opened up sufficiently to allow wagons to pass over it with difficulty. The work was done by contract and was paid for from the unexpended balance of the appropriation for the preceding year, $5,939.10; still unfinished, but used to present date. The road around the Norris Hill constructed the previous year was improved; cost, $1,760.21. The new road commenced the previous year from the Fountain Geyser to the Excelsior Geyser was completed 2 miles; cost, $1,856.50; used to present date. The new road along the rapids above the Upper Falls of the Yellowstone River commenced the previous year was finished; cost, $3,737.32.

The retaining walls were rebuilt in 1896–97, road used to present date.

Part of the new road toward Inspiration Point; cost, $1,607.26; used to present date.

A wooden arch bridge was built over a ravine on the new road near the Upper Falls of the Yellowstone, 180 feet long, 52 feet high; cost, $9,612.45; used to present date. A four-span crib pier bridge was buit over the Lamar River on the old road to the east boundary. Logs and poles not hewn were used; cost $847; used to present date.

A line was surveyed for a proposed road from a point on the Gardiner River near Boiling River to Undine Falls on the East Fork of the Gardiner River. Project was abandoned and road built on a different alignment in 1897.

The beach road, along the shore of the Yellowstone Lake, was improved and surfaced; cost, $4,911.08; abandoned after season of 1898.

Granite monuments were set up near the outlet of the Yellowstone Lake to mark the meridian and astronomical point determined by the United States Coast and Geodetic Survey. Signboards with names and distances painted thereon were erected at all road terminals, and cedar mileposts, properly marked, were placed on the entire road circuit then constructed, except between Norris and the Upper Basin.

Necessary repairs at various points on belt road, erecting monuments and mileposts and repairs during spring of 1894; cost, $5,668.18.

Roads built marked on accompanying map.

New work accomplished, 1893, including 2 bridges ....miles.. 6.5

Money statement, 1893.

Appropriated		$30,000.00
Balance from 1892 for uncompleted contract		5,939.10
Expended, new work	$21,145.37	
Completion and maintenance	14,793.73	
		35,939.10
Cost of construction per mile		3,253.00

Summary of work from March 3, 1883.

	Miles.
Roads constructed, including 65 bridges	129
Total milage abandoned:	
Wagon trails	87
Roads	5.8

Money statement from March 3, 1883.

Appropriated March 3, 1883, to March 3, 1893		$460,934.25
Expended, new work	$307,308.43	
Completion and maintenance	91,231.65	
Surveys	11,239.34	
Administration and protection	51,154.83	
		460,934.25
Total cost of constructing road to this date per mile		2,382.00
Amount estimated for completion of revised project (Major Jones's report, 1892)		365,100.00

An unusual amount of snow which remained late in the mountains caused the spring floods in 1894 to eclipse any previous records, and considerable damage was done at many points on the road circuit. A bridge spanning the Gardiner River on the road between Mammoth Hot Springs and the north entrance to the Park was carried away, and about 600 feet of retaining wall was washed out at different places on the same road. The roadbed was washed out to an extent that made travel over it dangerous at several points on the Gardiner Canyon, two places in the Gibbon Canyon, throughout nearly the whole length of Spring Creek, and the roadbed destroyed for some distance near Virginia Cascade. Many small bridges were washed away, and much inconvenience was caused to traffic of all kinds. The appropriation for that year had, unfortunately, been nearly all expended, and the small sum remaining on hand was altogether inadequate to accomplish the necessary repairs. A few small bridges were built in a temporary manner, and the worst places in the washouts were roughly filled.

An appropriation of $30,000 became available on August 18, 1894, and the direction of the work of improvement was placed in charge of Capt. George S. Anderson, Sixth United States Cavalry, acting superintendent of the Park. Immediately after receiving notice that the money was to be expended by himself, Captain Anderson placed Mr. O. Swanson, United States overseer, in charge of the working forces, and made preparations to repair the damaged roads and put the entire circuit in good condition,

The wooden arch bridge near the Upper Falls of the Yellowstone was completed; cost, $1,076.32; used to present date.

About 1 mile of new road was partially constructed to replace the portion of road washed out during the spring floods between the north entrance to the Park and the Mammoth Hot Springs, including a truss bridge of sawed lumber with a trestle approach over the Gardiner River; cost, $3,247.06; used to present date. The dangerous places in the Gibbon Canyon, near Grand Canyon, and Virginia Cascade were all repaired; cost, $2,685.22.

The work was again taken up early in the spring of 1895, with A. E. Burns, United States overseer, in charge of working forces under orders of Captain Anderson. On March 2, 1895, Congress appropriated $30,000; on June 8, 1896, $5,000, and on June 11, 1896, $35,000, of which sum not more than $5,000 were to be expended in the timber reserve south of the Park, making a total of $100,000, including the appropriation for 1894–95, with which amount the following improvements were accomplished:

A road was constructed from the Gibbon Canyon to the ford on Nez Perce Creek, cutting out the old dangerous road over the hill and filling the gap hitherto existing in the belt line at that point; about 7 miles of new road; cost, $9,879.34; used to present date. From a point on this road near the falls of the Firehole River, a road was constructed down the Firehole and Madison rivers, 7½ miles, toward the west boundary of the Park, including a Howe truss bridge with trestle approach over the Gibbon River near its mouth and a three-span bridge of two Howe trusses and one King truss over the Madison River near Riverside; cost, $9,651.66; used to present date.

From a point near Lewis Lake a line was surveyed to the south boundary of the timber reserve, the right of way was grubbed and cleared the whole distance, and the road made passable for vehicles from the south entrance to the Park near Snake River to a junction with the main road circuit at the West Thumb of the Yellowstone

Lake. It includes a two-span Howe truss bridge over the Snake River near the mouth of Pole Cat Creek and several small bridges; about 20.5 miles of road partly built, cost, $12,902.50; road still unfinished, but used to present date.

For the proposed road from the Grand Canyon to Mammoth Hot Springs, via Mount Washburn, a line was surveyed the whole distance. The right of way was grubbed and cleared for 9 miles from the Canyon Hotel toward the summit of Mount Washburn, and 2 miles of wagon road was constructed at the same point; cost, $6,088.67; road not yet open for travel.

For the proposed road from the east boundary of the Park to join the belt road at Yanceys, a line was surveyed from the boundary to Soda Butte. Six miles of right of way was grubbed and cleared and 5 miles of road constructed; cost, $5,671.52; completed portion of road used to present date.

A piece of road was built near the Devils Frying Pan to eliminate an objectionable hill at that point; cost, $312.30; used to present date.

A Howe truss bridge with a trestle approach was erected over the Gibbon River near the north end of the Gibbon Canyon, where a dangerous ford had been in use; cost, $1,090.06; used to present date. A Howe truss bridge with trestle approach was erected over the Firehole River near the Excelsior Geyser, enabling the road from the Fountain Geyser Basin to the Upper Geyser Basin to be carried nearer the objects of interest at that point; cost, $1,201.93; used to present date. A trestle bridge on sawed lumber bents was erected over a small stream near the West Thumb on the road to the Lake Outlet, where a ford has previously been in use; cost, $362.25; used to present date.

Side roads to various points were built as follows:

Improved a portion of the old road and constructed nearly 2 miles of new road along canyon's brink from the Grand Canyon Hotel to Inspiration Point, 2 miles; cost, $2,924.26; used to present date. A loop road from the main circuit between the Grand Canyon and the Yellowstone Lake Outlet to Sulphur Mountain, 3 miles; cost, $807.53; used to present date. A branch road from the mouth of Spring Creek, on the Firehole River, to the Lone Star Geyser; cost, $53.75; used to present date. A branch road from a point on the main circuit between the Yellowstone Lake Outlet and the West Thumb to the Natural Bridge; cost, $98.58; abandoned 1898. A loop road from near the Fountain Hotel to the Great Fountain and the Black Warrier Geysers, 1 mile; cost, $523; used to present date. A loop road to Iron Spring Creek at Upper Geyser Basin, 1 mile; cost, $320.17; used to present date.

A small warehouse, two workshops, and a wagon shed were erected at Mammoth Hot Springs; cost, $689.44; used to present date.

Ten water-closets were built at convenient points on road circuit; cost, $172.86.

Lumber for repair work and other purposes, in addition to that used for bridge construction, was sawed and stacked for use; cost, $5,477.54.

Cedar mileposts, properly marked, were placed on the road between Norris and the Upper Basin and the road to the west boundary, thus finishing the marking of distances commenced in 1893; cost, $86.68.

Stone monuments, properly inscribed, were placed on the east and south shore of Yellowstone Lake and on the west shore of Shoshone Lake. Measurements were made from these points to determine the exact location of the Park boundaries, and monuments were erected on the east, south, and west lines, and at the southeast corner. This work was executed under the personal direction of Lieut. Charles S. Bromwell, Corps of Engineers, who was detailed on special duty in the Park for the purpose. He also surveyed portions of the east, south, and west boundaries, plainly marking the same by cutting a strip in the timber 6 feet wide and by erecting posts and rough stone monuments across the open sections on the cliffs; cost, $4,365.24.

The exact altitude of a point on the Northern Pacific Railway, at Cinnabar, Mont., was obtained from the engineer officers of that company, and a line of levels run from thence, via Mammoth Hot Springs, Norris, Grand Canyon, and Lake Outlet, to the West Thumb. The altitudes were plainly marked on the mileposts over this portion of the circuit and on the stone monument near the Yellowstone Lake Outlet. The exact latitude and longitude, as previously determined by the Coast and Geodetic Survey, was also carved on the monument; cost, $305.

Improving and completing various portions of road circuit; cost, $9,568.57.

General maintenance of entire road circuit and repairing and rebuilding bridges and culverts; cost, $11,667.53.

Shoveling snow to open roads for travel in the spring of 1896; cost, $914.10.

Winter expenses (1894–95, 1895–96, and 1896–97), traveling expenses, instruments, and contingencies; cost, $1,856.92.

For purposes of general protection, fiscal year ending June 30, 1895, $2,000, and fiscal year June 30, 1896, $2,000. For fiscal year ending June 30, 1897: New station at Snake River, repairs to station at Soda Butte, and salaries of scouts, $2,000.

Roads built marked on accompanying map.

New work accomplished 1894–95–96, including 7 bridges ....miles.. 40

Wagon trails abandoned, 24 miles (Norris).
Roads abandoned, 1.5 miles (Kingman).

Money statement 1894–95–96.

Appropriated		$100,000.00
Expended, new work	$58,511.10	
Completion and maintenance	29,756.36	
Survey	305.00	
Buildings	862.30	
Administration and protection	10,565.24	
		100,000.00
Cost of construction per mile		1,462.00

Summary of work from March 3, 1883.

	Miles.
Roads constructed, including 72 bridges	169
Total mileage abandoned:	
Wagon trails	111
Roads	7.3

Money statement from March 3, 1883.

Appropriated March 3, 1883, to June 11, 1896		$560,934.25
Expended, new work	$365,819.53	
Completion and maintenance	120,988.01	
Surveys	11,544.34	
Buildings	862.30	
Administration and protection	61,720.07	
		560,934.25
Total cost of constructing road to this date, per mile		2,164.00

On June 4, 1897, an appropriation of $35,000 was made, of which amount $5,000 was immediately available.

The work of repairing and opening up the roads for the season's travel was commenced and preparations were made for carrying on the work of general improvement.

On June 24, 1897, Col. S. B. M. Young, Third Cavalry, was appointed to succeed Captain Anderson as superintendent, and under his direction the following work was accomplished:

A party under the immediate direction of Lieut. Charles S. Bromwell, Corps of Engineers, completed the work of determining and marking the south boundary to a point about 7 miles from the west boundary. A second party determined and marked 16 miles of the north boundary. The work was similar to that executed in 1896, and cost $3,455.88.

A survey was made and a line located for a road from Riverside to the west boundary, the right of way was grubbed and cleared, and the road partly built; length, 4 miles; cost, $2,112.26; used to the present date.

On the proposed approach from the east boundary a road was built from a point about 1¾ miles from the Mammoth Hot Springs along the south bank of the east fork of the Gardiner River to a junction with the old road above Undine Falls about 5½ miles from the Mammoth Hot Springs; length, 3¼ miles; about 3 miles finished, including a one-span Howe truss bridge over the main fork of the Gardiner River and a one-span bridge over the east fork of the Gardiner River; cost, $9,448.70; used to present date.

Between Soda Butte and the east boundary on the proposed approach road a portion of the line was relocated and about 4 miles of right of way was grubbed and cleared; cost, $1,263.24; road not yet completed.

A survey was made and a line determined on for a road down the Gibbon River from Elk Park to Gibbon Meadows and the work of grubbing and clearing the right of way was begun; cost, $204.66; road completed in 1898 and used to present date.

Preliminary surveys were made for a proposed road from Mammoth Hot Springs to Golden Gate, and for a new location of the road over Mount Washburn.

A line of levels was run and the altitudes marked on the mile posts from Norris to the West Thumb via Fountain and Upper Basin; cost, $227.33.

Improvements were made in the driveways to the Mammoth and Canyon hotels, and guard rails were constructed at various points along the brink of the Grand Canyon; cost, $680.10; used to present date.

One hundred and eighty-three thousand five hundred feet of lumber was sawed for general repairs (in addition to that used in the construction of bridges) and stacked at convenient places; cost, $1,878.31.

A one-span bridge of sawed lumber was built over the Gibbon River in Virginia Meadows. A one-span King truss bridge was built over Trout Creek between the Grand Canyon and the Yellowstone Lake. A one-span truss bridge with trestle approach was built over the Firehole River near Riverside Geyser; cost of the three bridges, $676.93; all used to present date.

Special efforts were made during this season to complete many portions of the belt road hitherto unfinished. More than one-third of the entire appropriation was expended on such work and on general repairs, with the result that the entire circuit was brought to a degree of excellence never before attained; cost, $11,171.33.

Winter expenses (1897–98), traveling, and contingencies cost $600.40.

For purposes of general protection a soldier outpost station was erected at Norris, and the outpost stations at Riverside and Mud Geyser were repaired. Rations and cooking outfits were placed at all the snow-shoe cabins and necessary scouts were hired; cost, $3,280.86.

Roads built marked on the accompanying map.

New work accomplished, 1897, including five bridges .... miles..	9

Wagon trails abandoned, 12 miles (Norris).

Money statement, 1897.

Appropriated		$35,000.00
Expended, new work	$13,124.60	
Completion and maintenance	14,706.67	
Survey	431.99	
Administration and protection	6,736.74	
		35,000.00
Cost of construction per mile		1,458.29

Summary of work from March 3, 1883.

	Miles.
Roads constructed, including 77 bridges	178
Total mileage abandoned:	
Wagon trails	123
Roads	7.3

Money statement.

Appropriated March 3, 1883, to June 4, 1897		$595,934.25
Expended, new work	$378,944.13	
Completion and maintenance	135,694.68	
Survey	11,976.33	
Buildings	862.30	
Administration and protection	68,456.81	
		595,934.25
Total cost of constructing road to this date, per mile		2,128.00

On July 7, 1898, an appropriation of $40,000 was made. On November 15, 1897, Colonel Young left the Park, and the duties of the acting superintendent devolved on Capt. James B. Erwin, Fourth Cavalry, who was next in command and who remained in charge until March, 1899, during which time the amount was expended as follows:

A route was decided on and preliminary surveys made for a proposed road over the east side of Mount Washburn, between the Canyon Hotel and Yanceys, and for a proposed new road through the Gardiner Canyon, between Mammoth Hot Springs and the north boundary; cost, $439.63.

The location of the west boundary line of the Park was marked by cutting a clearing 6 feet wide through the timber and erecting posts and stone monuments across the open spaces for 40 miles from the monument erected by Lieutenant Bromwell toward the north boundary; cost, $2,085.25.

The road from Elk Park to the Gibbon Meadows, which was commenced the previous year, was finished. Length, 2 miles; cost, $5,667.19. Used to present date.

Work was commenced on the proposed new road from Mammoth Hot Springs to Golden Gate, a location for which had been surveyed the previous year, and a rock fill with a loose-rock retaining wall to replace the wooden trestle at Golden Gate was also begun; cost, $3,675.40. About one-half of the road work was abandoned consequent on a new location being decided upon when the new road was built in 1899. The project for building the loose-rock wall was changed to admit of more extensive improvements, in the execution of which the portion already built will be utilized as far as possible.

A small piece of new road was built to cut out a bad hill near the Devils Frying Pan. The road to the natural bridge was improved by building a driveway to the foot of the bridge. Several short pieces of road were built at Mammoth Hot Springs and around Fort Yellowstone. Total, 3.3 miles; cost, $1,491.95. All still in use. A shelter for tourists was built at Norris. A bridge was constructed on the bridle trail to Bunsens Peak. Wooden sidewalks were laid at Mammoth Hot Springs and guard walls and railings, platform, seats, and steps were placed at various points; cost, $638. All still in use. Lumber of various dimensions was sawed in addition to that used for building; 253,330 feet, at $9 per thousand feet; cost, $2,280.

Completing and improving various portions of the road circuit and general repairs; cost, $10,313.53.

Expenses during winter of 1898–99: Contingencies, freight, etc.; cost, $315.44.

Material was purchased for buildings, bridges, and other improvements, which were projected but not built. A road sprinkler and other plant were also purchased; total cost, $3,822.29.

For purposes of general protection four substantial log houses were built, with barns and outbuildings for soldier outpost stations, at Lower Geyser Basin, Upper Geyser Basin, Lake Outlet, and Grand Canyon; cost, $3,825. Nineteen log cabins were built for the use of patrol parties during the winter, and five cabins previously built were repaired; cost, $1,739.25. Lumber sawed for building and general repairs connected with the protection of the park; cost, $2,000.

Traps and corrals for catching and keeping wild animals, and footbridge for winter patrol parties; cost, $235.07.

Salaries of scouts, winter expenses 1898–99, and contingencies; cost, $1,472.

Roads built marked on accompanying map.

New work accomplished 1898 ... miles	6.3

Roads abandoned, 2 miles, Sears; 1.2 miles, Anderson; 1 mile, Kingman.

Money statement, 1898.

Appropriated		$40,000.00
Expended, new work	$10,949.98	
Completion and maintenance	13,431.53	
Survey	439.63	
Buildings	3,822.29	
Administration and protection	11,356.57	
		40,000.00
Cost of construction per mile		1,738.00

Summary of work from March 3, 1883.

	Miles.
Roads constructed, including 77 bridges	184.3
Total mileage abandoned:	
Wagon trails	123
Roads	11.5

Money statement.

Appropriated March 3, 1883, to July 1, 1898		$635,934.25
Expended, new work	$389,894.11	
Completion and maintenance	149,126.21	
Survey	12,415.96	
Buildings	4,684.59	
Administration and protection	79,813.38	
		635,934.25
Total cost of construction to date per mile		2,115.00

On March 3, 1899, an appropriation of $40,000 was made, of which $5,000 was immediately available. In the same month Captain Erwin was succeeded by Capt. W. E. Wilder, Fourth Cavalry, under whose direction the usual spring repair work was carried on until March 25, 1899, when Capt. Hiram M. Chittenden, Corps of

Engineers, was placed in charge of the work of constructing and maintaining roads and bridges, under orders of the Chief of Engineers. The completion of the project and the disbursement of all funds pertaining thereto was transferred to the sole charge of the United States Engineer Department. Captain Chittenden prepared and submitted a carefully revised project for the completion of the belt road, the various approaches, and the necessary side roads to important points, at an estimated cost of $310,000.

In view of the fact that the appropriation since 1894 had been drawn on for funds for the purpose of protecting the Park, a claim was made that a portion of the current appropriation should rightfully be expended for that purpose. The sum of $4,500 was accordingly transferred to the acting superintendent to be disbursed by him in payment of expenses incidental to general protection, and the cost of building one soldier station and repairing others it was agreed should be paid from the funds allotted for improvement of roads and bridges. The work accomplished was as follows:

A road was built from the Mammoth Hot Springs to Golden Gate, a portion of the roadway built the previous year was included in the new alignment, and 16,500 feet, or about 3.1 miles, of road was finished; cost, $17,422.56.

For the proposed new road through Gardiner Canyon a survey was made and the line located the whole length. A steel bridge with concrete abutments was erected, and a short piece of road was built; cost, $2,865.15.

A reconnaissance was made for a proposed road to shorten the route to the west boundary, and a 2-span crib-pier trestle bridge was built over the Gibbon River at the east end of the new road. A 2-span bridge was built over the Gibbon River above the Virginia Cascade to replace one worn out; cost, $228.33.

Preliminary surveys were made to decide on the best location for the proposed road over Mount Washburn and for the road to the east boundary; cost, $254.75.

Many parts of the road circuit were improved by cutting down small hills, filling depressions, grading some unfinished portions, and generally repairing the entire road system. Four small section crews were also placed on the belt roads and rendered valuable assistance in the work of general repairs; cost, $9,782.05.

Winter expenses 1899 and 1900, traveling expenses, and contingencies; cost, $1,173.36.

Commencement of new road to shorten the distance to west boundary and opening roads and general repairs in the spring of 1900, $2,739.16.

For purpose of general protection, a substantial building of trimmed logs, with barn and outbuildings, was constructed for a soldier outpost station at Riverside near the west boundary. Five other stations were improved and repaired, and the sum of $4,500 was transferred to the acting superintendent for use in protecting the game and for salaries of scouts and clerk, $5,534.64.

Roads built marked on accompanying map.

New work accomplished 1899, including 3 bridges, equal to ....miles.. 6.7

Roads abandoned, 3 miles, Kingman.

Money statement, 1899.

Appropriated		$40,000.00
Expended, new work	$22,016.04	
Completion and maintenance	12,194.57	
Surveys	254.75	
Administration and protection	5,534.64	
		40,000.00
Cost of construction per mile		3,286.00

Summary of work from March 3, 1883.

	Miles.
Roads constructed, including 80 bridges	191
Total mileage abandoned:	
Wagon trails	123
Roads	14.5

Money statement.

Appropriated March 3, 1883, to March 3, 1899		$675,934.25
Expended, new work	$411,910.15	
Completion and maintenance	161,320.78	
Surveys	12,670.71	
Buildings	4,684.59	
Administration and protection	85,348.02	
		675,934.25
Total cost of construction to date, per mile		2,156.00

Summary.

Total amount appropriated, June 20, 1878, to March 3, 1899, for improvement and protection		$744, 359. 42
Expended, June 20, 1878, to June 30, 1883, for construction and maintenance of roads and bridges and administration and protection	$68, 425. 17	
Expended, July 1, 1883, to June 30, 1900, for construction and maintenance of roads and bridges	590, 586. 23	
For administration and protection	85, 348. 02	
		744, 359. 42

		Miles.
Wagon trails built 1878 to 1882, about		160
	Miles.	
Wagon trails abandoned to June 30, 1900, about	123	
Wagon trails still in use, Mammoth Hot Springs to east boundary	37	
		160
Roads built 1883 to 1900		191
Roads abandoned to June 30, 1900	14. 5	
Roads still in use	176. 5	
		191

MILEAGE OF ROAD SYSTEM OF THE YELLOWSTONE NATIONAL PARK.

Approaches.

	Miles.
Northern: North boundary near Gardiner to belt line at Mammoth Hot Springs	5
Eastern:	
Park boundary near northeast corner to belt line near Yanceys	27
East boundary near Middle Creek to belt line near Yellowstone Lake Outlet	27
East boundary of Park to east boundary of timber reserve, 20 miles.	
Southern:	
South boundary near Snake River to belt line near West Thumb	23
South boundary of Park to south boundary of timber reserve, 10 miles.	
Western:	
West boundary near Riverside to junction of the Gibbon and Firehole rivers	14
Junction of Gibbon and Firehole rivers up the Firehole River to the belt line	2
Junction of Gibbon and Firehole rivers up the Gibbon River to the belt line	4
	102
In timber reserve	30
Total	132

Belt line.

	Miles.
Mammoth Hot Springs to Norris	20
Norris to Fountain	20
Fountain to Upper Basin	9
Upper Basin to West Thumb	19
West Thumb to Lake Outlet	15
Lake Outlet to Canyon Junction	16
Canyon Junction to Canyon Hotel	1
Canyon Junction to Tower Falls	19
Tower Falls to Mammoth Hot Springs	24
Canyon Junction to Norris, crossroad	11
Total	153

Side roads.

	Miles.	
At Mammoth Hot Springs:		
Around Hot Springs Terraces	1	
To Osprey Falls and Bunsens Peak	5	
To Mount Everts via Undine Falls	2	
		8
At Fountain: To Great Fountain and Hot Springs		3

	Miles.	
At Upper Basin:		
Loop from mouth of Nez Perce Creek to Prismatic Lake	4	
To Biscuit Basin	1	
To Iron Spring Creek and Black Sand Basin	2	
To Lone Star Geyser	1	
		8
Lake shore road: Loop from near Bluff Point to near Natural Bridge		12
River road: To Sulphur Mountain		1
At Grand Canyon:		
To southeast side of Grand Canyon, along right bank	3	
To Inspiration Point	3	
		6
Mount Washburn road: Loop from Dunraven Pass over Mount Washburn		7
Total		45

SUMMARY.

	Miles.
Approaches in Park	102
Approaches in forest reserve	30
Total	132
Belt line	153
Side roads	45
Total mileage of Park system	330

	Miles.	
Mileage completed June 30, 1900:		
Approaches	30	
Belt line	106	
Side roads	27	
		163
Remaining to be completed:		
Approaches in Park	72	
Approaches in forest reserve	30	
Belt line	47	
Side road	18	
		167
Total		330

Omitting the 30 miles in the forest reserve, the final mileage of the completed system will be 300 miles, of which 163 miles are now in use and 137 miles remain to be completed.

Respectfully submitted.

A. E. Burns,
United States Overseer.

Capt. Hiram M. Chittenden,
Corps of Engineers, U. S. A.

Appendix C.

REPORT OF MR. A. E. BURNS, OVERSEER.

United States Engineer Office,
Sioux City, Iowa, June 30, 1900.

Captain: As directed by you, I beg to submit herewith a report of operations pertaining to general repairs of roads and bridges in the Yellowstone National Park during the fiscal year 1900:

On May 1, 1899, I received a communication from yourself directing me to start operations in accordance with a project previously submitted, to open the road circuit for the early travel, and afterwards execute all necessary repairs.

A small crew was at once organized and work commenced at the north entrance to the Park near Gardiner. The hill at the south end of the McCartney grade was cut

down to an easy gradient and the road through Gardiner Canyon was much improved by cutting off many of the raises in the roadway and filling the depressions. A substantial guard rail was erected along the entire length of the McCartney grade, adding much to the appearance of the road and insuring safety for travelers. The fence is of squared cedar posts, fir-pole top rails, and 2-inch plank bottom rails and braces. An old bridge over a coulee near the State line was replaced by a new and better structure. The road between this point and the 1-mile post from the Mammoth Hot Springs was straightened and widened. The road was crowned over its entire length, all bridges and culverts were redecked where necessary, ditches were cleaned and retaining walls and slopes were repaired and trimmed. From Mammoth Hot Springs to about 1 mile toward the north entrance the roadway was surfaced with gravel 18 inches in center and 6 inches at the edge. The road to Golden Gate was repaired only so much as would make it safe for travel during the time the new road was being built to that point.

After completion of this work the crew opened the roads to the West Thumb of Yellowstone Lake via Norris and Grand Canyon. Their work consisted principally in shoveling snow and cutting out fallen timber. The heaviest work was between Norris and the Grand Canyon, where it was necessary to shovel an opening for the roadway nearly the whole distance. On the 1st of June a second crew was organized and dispatched to Norris, at which point they commenced operations, opening the road to the West Thumb via the Fountain and Upper Basin.

When the entire road circuit was opened for tourist travel attention was directed to general repairs. Four section crews were organized and placed on their respective stations and a repair crew was engaged from June 1 to August 7 in completing many parts of the road circuit previously unfinished. The road from Mammoth Hot Springs to Soda Butte was repaired only where absolutely necessary. A new span was built in the bridge over the Lamar River to replace one washed out by high water, some small bridges and culverts were redecked, and the roadway cleared of rock and débris.

Between Golden Gate and Norris the road was crowned with grading and leveling machines, and portions were resurfaced. The material used, though not in all cases the most desirable, was the best that could be obtained in that locality. All ditches and culverts were cleaned, and the banks on side hill and through cuts were neatly sloped. In many places the road was straightened and improved by cutting off projecting points, flattening sharp curves, grading down many small hills, and raising low places.

A portion of the road near Brickyard Hill was made impassable by an increase of the surface springs in the clay bed over which the road is built. As neither funds nor time would permit the rebuilding of the road it was deemed advisable to use corduroy. Green fir logs 8-inch to 14-inch butts, were laid over the length of soft road and entirely covered with a surfacing of gravel, thus making one of the worst places on the road circuit a good (temporary) road, although by means not always to be recommended.

The bridges over Glen Creek, Gardiner River, Willow Creek, Obsidian Hill, and the Gibbon River were all redecked, and many culverts were rebuilt.

Between Norris and the Grand Canyon the road suffered considerably from washouts caused by the rapid melting of the snow, which had remained in large quantities until very late in the season. The road was constantly patrolled until the bulk of the snow had disappeared, thus undoubtedly preventing more serious damage. The roadbed was badly washed in several places near the Virginia Cascade, on the Blandon Hill, and between the 1-mile post and Canyon Junction. The approaches to the bridge over the Gibbon River near Virginia Cascade were washed out, making the bridge almost impassable and very dangerous. A new 2-span bridge was built, all washouts were repaired, and the whole length of the road was treated in a similar manner to the road between Mammoth Hot Springs and Norris. The sharp and dangerous turn in the road near Cascade Creek was cut out and the road widened. The road to Inspiration Point was smoothed and leveled, all fences along the canyon brink were examined and repaired where necessary and the bridle and foot trails were improved. Between the Grand Canyon and the Yellowstone Lake the roads were very soft in consequence of the great quantity of snow remaining after the heavy travel commenced, and some small washouts occurred near the large drifts.

The roadbed was cleared of snow, all ditches and culverts were opened and washouts repaired. When the surface had become sufficiently dry it was crowned and smoothed by the use of road-grading machines. The bridge over Sulphur Creek became unsafe in consequence of the foundation washing away under one of the bents. A new foundation was built and all the bents were more stoutly braced.

All culverts, bridges, and retaining walls were inspected and repaired, and many sections of the roadway were resurfaced.

Much damage was caused on the lake shore road between the Outlet and the West Thumb by the unprecedented high water. A bridge on the sand bar, 6 miles from the Thumb, was rendered impassable by the foundation washing out and the consequent sinking of the bridge. A temporary road through the timber was opened around this point, which was continued in use all summer, as it was not considered advisable to repair the bridge in view of the fact that this portion of the road might be abandoned entirely. Across the hot-spring basin near the Thumb the roadway was submerged, a trail was opened around it for use until the water fell sufficiently to allow the road to be repaired.

On the road around Bridge Bay the poles comprising the corduroy across the sand bar were undermined and in many places washed away and the approaches to the two bridges on the bar were washed out. This portion of the road was constantly patrolled during the period of high water and afterwards repaired sufficiently to insure perfect safety.

Between the West Thumb and Bluff Point the portions of the road previously unfinished were completed and the entire road thoroughly repaired. Very little damage was done by the spring floods between the West Thumb and the Upper Geyser Basin. A few small washouts occurred in Spring Creek Canyon. These were repaired and the retaining wall was strengthened in many places; all bridges and culverts were carefully examined and repaired where necessary; the roadway was crowned and resurfaced in places; the drainage ditches were cleaned, and the slope and cuts were trimmed. From the Upper Geyser Basin to Norris via the Fountain a large amount of repair work was found necessary. Two bridges over the Firehole River and one over a creek near the Artemesia Geyser were redecked, many new culverts were built and old ones repaired.

Considerable resurfacing was done near the Fountain Hotel, and all the side roads through the Geyser Basin and to all points of interest were repaired.

The road through the Gibbon Canyon was carefully watched during the time of the high water. All breaks in the retaining walls were immediately repaired, and all possible precautions were taken to prevent damage to the roadbed. After all danger was past the retaining walls were examined and repaired, the roadbed resurfaced, culverts redecked, and the damaged bridge crossing the Gibbon River was temporarily repaired pending the erection of a new one next season.

A two-span log crib pier bridge was erected over the Gibbon River on a proposed shorter road to the west boundary. The road across Gibbon Meadows and Elk Park was leveled and resurfaced and the new road between these two points was crowned and repaired.

A small crew passed over the road from the West Thumb of the lake to the south boundary, removed fallen trees, repaired washouts, leveled all rough places, and generally repaired the whole road in as effective a manner as its unfinished condition would permit.

In accordance with an agreement between yourself and the acting superintendent of the Park, a new military outpost station was built at Riverside near the west boundary.

The building was constructed of logs, squared on three sides and sized, matched lumber finishing, shingle roof, and brick chimney, three living rooms and a frame kitchen.

The stable is built in a similar manner and contains four double stalls and a loft. A woodshed and outbuildings were also erected.

The stations at Norris, Fountain, Upper Basin, Yellowstone Lake, and the Grand Canyon were plastered with mortar between the logs and repaired wherever necessary.

During June, 1900, three repair crews were organized and commenced work of placing the roads in condition for the coming season's travel. The road from this point to the north boundary (the principal entrance to the Park) was thoroughly repaired and placed in good condition for the ensuing season's travel. Portions of the newly constructed road to the Golden Gate were surfaced with carefully selected material, and the whole length of the road trimmed and improved. Between the Golden Gate and Norris a little surfacing was all that was found necessary. From Norris to the Yellowstone Lake outlet, via Fountain, Upper Geyser Basin, and West Thumb, the roads were placed in a thorough state of repair. Considerable work was found necessary in the Gibbon Canyon, where large quantities of rock and débris had slid into the road, and near the Gibbon Falls, where the melting snow had filled the sidehill grades with earth and stone. In Spring Creek Canyon the retaining walls were broken in many places, and in a few instances the roadbed had been overflowed during high water. All damaged portions were repaired and weak spots were strengthened.

Between the crossing of the Continental Divide and the Yellowstone Lake the road had been badly washed, making it very rough in places. Good gravel was hauled to these points and the roadbed resurfaced.

The roadbed, bridges, and culverts between Norris and the Yellowstone Lake outlet, via the Grand Canyon, were carefully examined and repaired where necessary; culverts were rebuilt and bridges redecked. The retaining wall on the road forming the approach to the Canyon Hotel was badly broken in several places, necessitating a large amount of work. The grade at such places was widened, allowing the traffic to pass along at a safe distance from the broken edges, where the ground was left to assume its natural slope, thus eliminating the necessity of the objectionable and sometimes dangerous walls.

The entire belt road is now in good condition, with the exception of the dusty portions, which are perhaps worse than usual owing to the continued dry weather.

A location was decided on for a road down the north bank of the junction of the Gibbon and Firehole rivers. The right of way was grubbed and cleared the whole distance and such grading was done as was necessary to make the road safe for travel pending further appropriations. This road will shorten the distance to the western entrance to the Park by nearly 3 miles.

All bridle trails, footpaths, and side roads connected with the belt line were cleared and repaired for travel. The old buildings used as offices and warehouses were slightly improved by a coat of whitewash and a little paint.

Very respectfully, your obedient servant,

A. E. Burns,
Overseer.

Capt. Hiram M. Chittenden,
Corps of Engineers, U. S. A.

Appendix D.

GENERAL PLAN OF ROADS AND IMPROVEMENTS FOR YELLOWSTONE NATIONAL PARK, APPROVED BY THE CHIEF OF ENGINEERS OF THE ARMY, PREPARED IN PURSUANCE OF ACT OF CONGRESS APPROVED JUNE 6, 1900.

Improvement Yellowstone National Park,
United States Engineer Office,
Mammoth Hot Springs, Wyo., August 20, 1900.

General: In compliance with instructions contained in your letter of June 12, 1900, I have the honor to submit herewith a general plan for road extensions and improvements in the Yellowstone National Park.

The road system of the Yellowstone National Park is designed to give access to the many natural objects of interest which abound throughout that region. It may be considered under three heads:

1. The belt line or general circuit, which passes or is to pass through all the more important centers of interest.

2. The approaches, by which travel reaches the belt lines from the boundaries of the Park.

3. Side roads and trails, which are to give access to isolated objects of interests or are to serve the special purposes mentioned further on.

The belt line.—There are six principal centers of interest in the Park. Three of them—the Mammoth Hot Springs, the Norris Geyser Basin, and the Firehole Geyser Basin—are located on a nearly north and south line and are, roughly speaking, 20 miles apart. The other three—the Yellowstone Lake, the Grand Canyon of the Yellowstone, and the open Park country around Tower Falls at the northern base of Mount Washburn—are likewise located approximately on a north and south line about 20 miles to the eastward of the first.

The belt line is to include these six localities, and travel will probably always pass around the circuit to the left.

The line from Mammoth Hot Springs to Norris is definitely fixed and constructed, and no future changes of importance in the alignment are proposed.

From Norris, via the Gibbon and Firehole rivers, past the Fountain Hotel to the Upper Geyser Basin, the general alignment is fixed, but the road is not yet all con-

structed. Additional work is required in the Gibbon Canyon and along all of that portion of the road through the Lower Geyser Basin.

From the Upper Geyser Basin to Outlet of the Yellowstone Lake the line is definitely fixed, except over that portion from the Thumb to the Outlet. It is proposed to carry the road directly over the hills from the Thumb Bay to Bridge Bay, thus shortening the distance 4 miles. From the Thumb to the Outlet the lake itself will be an important part of the route, and tourists will generally pass over this portion of the circuit by boat.

From the Lake Outlet to the Canyon Junction the line is definitely located and constructed and no changes of consequence are proposed.

From the Canyon Junction to Tower Falls the line is still unopened except for 1 mile from the Junction to the Canyon Hotel, and even this portion will require extensive modification to make it what it should be. It is proposed to carry the road across the Washburn Range through the low pass between Mount Washburn and Dunraven Peak, with a loop or side road passing over the Washburn summit.

From Tower Falls to Mammoth Hot Springs the line is still unlocated, except for about 2 miles near the East Gardiner Falls.

Connecting the east and west portions of the belt line at the points where they approach nearest each other is a cross road which may be considered a part of the circuit. It extends between Norris and the Grand Canyon and will always be an important road even when the circuit is entirely completed. The general location of this road will be as at present, but it will require radical modification and improvement in several places.

The total mileage of the belt line, including the cross road just referred to, will be about 153 miles.

The approaches will be four in number, one from each border of the Park. The northern approach extends from the north boundary near the mouth of the Gardiner River, up the valley of that stream to Mammoth Hot Springs, a distance of 5 miles. As the belt line here lies much nearer to a railroad than at any other point, and as the business and administrative headquarters of the Park, with the military post of Fort Yellowstone, are all located here, the northern approach will probably always remain the most important to the traveling public.

The eastern approach is located and begun, but is still incomplete. It extends up the valley of the North Fork of the Stinking Water River, across the forest reserve to the mouth of Middle Creek, and up the latter stream to Sylvan Pass, and thence to the Outlet of Yellowstone Lake. It enters the Park about 2 miles above the mouth of Middle Creek. The distance from the east boundary of the forest reserve to the belt line will be about 50 miles.

The southern approach extends from the elevated valley of Jackson Hole, up the Snake and Lewis rivers to the Lewis Lake, and thence to the belt line at the Thumb of the Yellowstone Lake. The length from the south boundary of the forest reserve is 33 miles. The whole line is located, but only partially constructed.

The western approach extends from the western boundary of the Park, where the Madison River leaves the reservation, up the Madison River to the junction of the Firehole. Here it forks, one branch ascending the Gibbon and the other the Firehole, until they intersect the belt line in the valleys of these two streams. This road is opened to travel, but is not yet definitely located over all its course, while some portions are only partially completed.

The total mileage of the approaches is 132 miles, of which 102 miles is in the Park proper and 30 miles in the forest reserve.

The side roads, trails, etc., are important adjuncts of the road system, giving access to points of interest off the main lines of travel. The following are the more important side roads:

Near Mammoth Hot Springs there will be a road leading around the terraces,

another to the Middle Gardiner Falls, and a third to Mount Everts. These roads are as yet only partially completed.

At the Lower Geyser Basin there is a branch of the main road which starts near the mouth of Nez Percés Creek, keeps mainly on the west side of the Firehole River, and joins the main road above Prismatic Lake. It is useful as a short cut for freight teams. From the Mammoth Paint Pots near the Fountain Hotel a side road leads to the Firehole Spring and the Great Fountain Geyser.

At the Upper Basin there will be a road passing among the various objects of interest. It is already partially completed. Three and one-half miles above the Upper Basin there is a road already opened leading to the Lone Star Geyser.

On the road along the Yellowstone River there is a loop about 3 miles long leading past Sulphur Mountain. It is only partially completed.

At the Grand Canyon there should be two side roads leading several miles down both banks of the canyon. One of these will require a bridge across the Yellowstone above the rapids. The road down the left bank has been constructed as far as to Inspiration Point, 2½ miles.

On the line between the Grand Canyon and Tower Falls there will be a loop about 4 miles long, leaving the main line at Dunraven Pass, extending across the summit of Washburn, and joining the main line to the north of the summit.

From near Tower Falls there is a road extending up the Lamar and Soda Butte valleys to the northeast corner of the Park. This road gives access to numerous objects of interest in the Lamar Valley, is useful in supplying the patrol station near Soda Butte, and gives a necessary highway for commercial purposes and for the United States mail to the mining districts on the northeast corner of the Park.

The total mileage of these side roads will amount to about 45 miles.

The trails of the Park are used mainly in patrolling the reservation; but also to a considerable extent by camping parties who are visiting portions of the Park not reached by the roads. They have been almost entirely neglected in recent years, and are consequently badly blockaded with fallen timber. Nothing is proposed in the line of extending these trails, but they should be maintained in passable condition.

Concerning the character of the work at present proposed, nothing is contemplated beyond securing a good grade, 18 feet wide, with a clearing through timber 30 feet wide, gradients nowhere exceeding 10 per cent, good side ditches, culverts, and bridges. In regard to the culverts and bridges it is proposed to use iron or tile for the culverts and steel and concrete for the bridges where these are located near enough to the railroad not to make the cost of transportation excessive. Further out in the Park, wood will be used as heretofore.

The present project and estimates do not contemplate the macadamization of the roads. While this will come in time, it will probably be done along with the current annual repairs, and its completion will be a matter of many years to come.

The detailed mileage of the road system, statement of past expenditures, and estimates of future cost, together with maps showing the location of the roads, are contained in the Annual Report of the Chief of Engineers for 1900.

Very respectfully, your obedient servant,

H. M. Chittenden,
Captain, Corps of Engineers, U. S. A.

Brig. Gen. John M. Wilson,
Chief of Engineers, U. S. A.

Office of the Chief of Engineers,
United States Army,
Washington, August 27, 1900.

Captain: Referring to your letter of the 20th instant, submitting a general plan for road extensions and improvements in the Yellowstone National Park, and to the detailed project contained in your Annual Report for the fiscal year ending June 30,

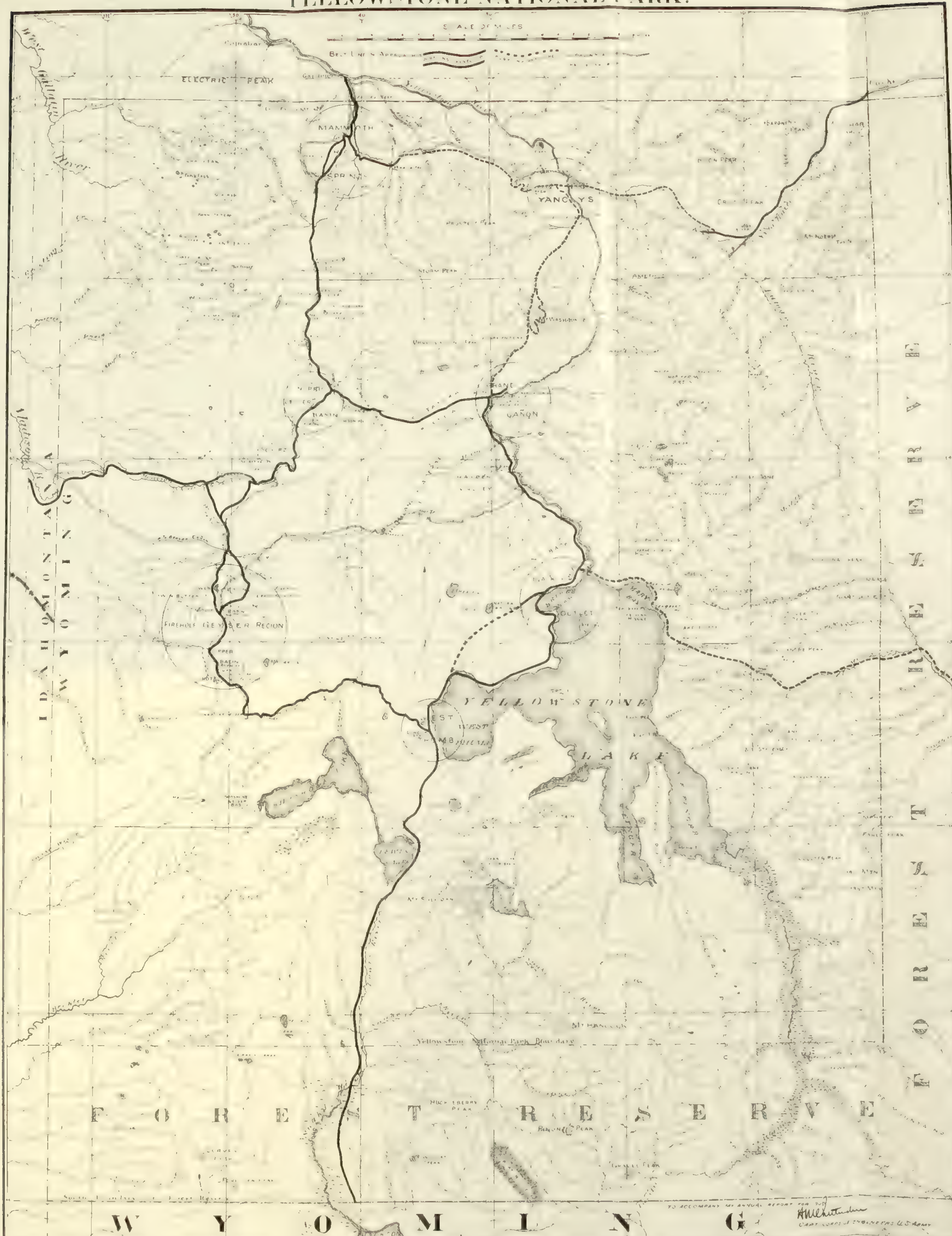
1900, I have to say that these projects, in my judgment, are in accord with the requirements of the sundry civil act of June 6, 1900, and, subject to such minor changes as may become necessary from time to time in the progress of the work, they meet with my approval. All road extensions and improvements carried on in the Park under the Engineer Department will hereafter be in harmony with these approved projects.

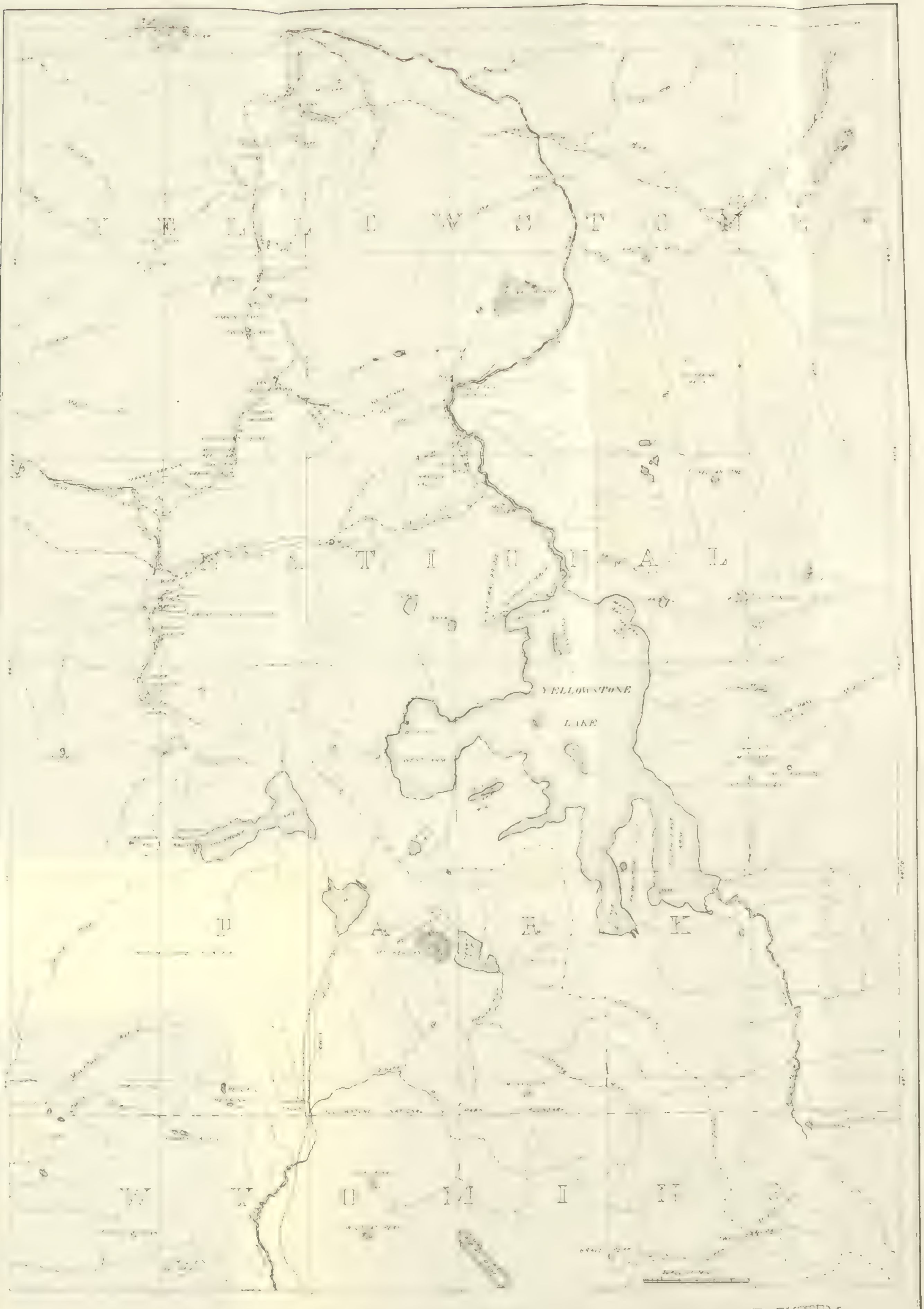
Very respectfully,

JOHN M. WILSON,
Brig. Gen., Chief of Engineers,
U. S. Army.

Capt. H. M. CHITTENDEN,
Corps of Engineers, U. S. A.

MAP OF TOURIST ROUTES.
YELLOWSTONE NATIONAL PARK.





MAP SHOWING DEVELOPMENT OF YELLOWSTONE NATIONAL PARK ROAD SYSTEM

Bridle trails

Maj W A Jones 1893.

Roads abandoned

FIG. 1.—METHOD OF WORKING SAND AND GRAVEL FOR GARDINER RIVER BRIDGE ABUTMENTS.

FIG. 2.—CONSTRUCTION OF CONCRETE ABUTMENT, GARDINER RIVER BRIDGE.

FIG. 3.—OLD WAGON BRIDGE REPLACED BY STEEL BRIDGE.

FIG. 4.—STEEL WAGON BRIDGE. CONCRETE ABUTMENTS. ERECTED 1899.

FIG. 5.—NEW ROAD ACROSS FOOT OF MAMMOTH HOT SPRINGS FORMATION.

FIG. 6.—NEW ROAD DOWN GOLDEN GATE HILL. BUILT SUMMER OF 1899.

FIG. 7.—NEW ROAD THROUGH "HOODOOS" NEAR GOLDEN GATE.

FIG. 8.—NEW ROAD THROUGH "HOODOOS," NEAR GOLDEN GATE.

FIG. 9.—NEW ROAD THROUGH "HOODOOS," NEAR GOLDEN GATE.

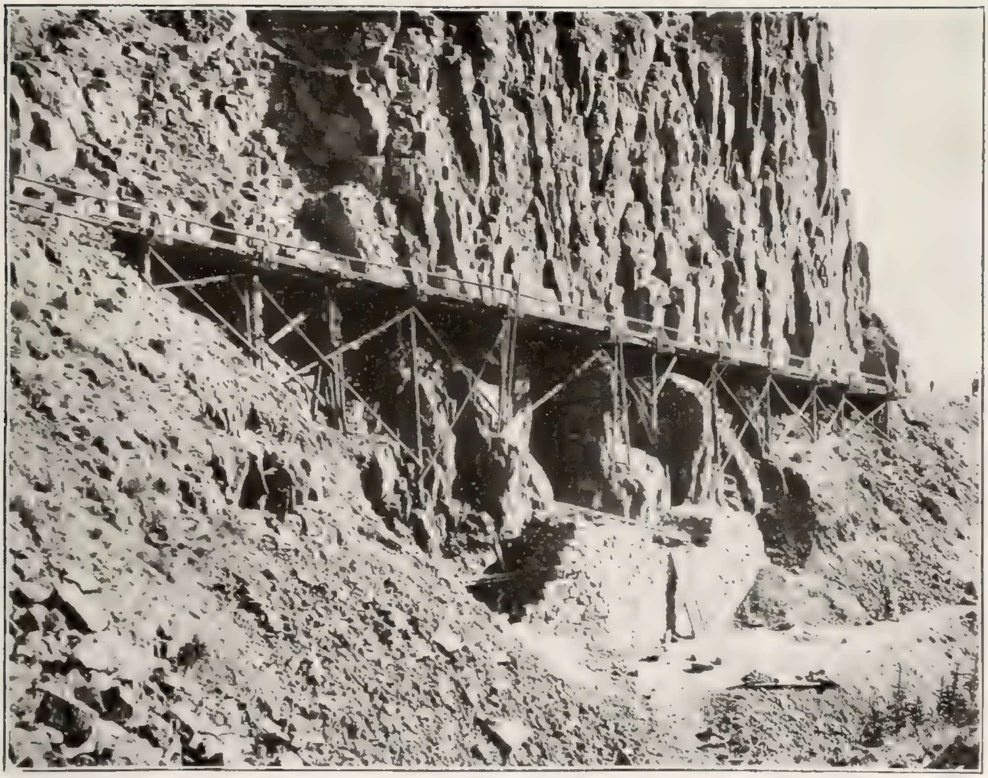


FIG. 10.—OLD GOLDEN GATE BRIDGE.

FIG. 11.—OLD GOLDEN GATE BRIDGE.

FIG. 12.—BROKEN BRIDGE. GIBBON CAÑON.

FIG. 13.—ROAD ALONG GIBBON RIVER.

FIG. 14.—ROAD ALONG GIBBON RIVER. RECENTLY OVERFLOWED AND PARTIALLY REBUILT.

FIG. 15—DANGEROUSLY NARROW ROAD ON SHORE OF LEWIS LAKE. SOUTHERN APPROACH.

FIG. 16.—PRESENT CONDITION OF SNAKE RIVER ROAD. SOUTHERN APPROACH.

FIG. 17.—BARONET BRIDGE, YELLOWSTONE RIVER. NOW UNSAFE FOR HEAVY LOADS.

FIG. 18.—BRIDGE SITE OVER THE YELLOWSTONE. LOOKING UP.

FIG. 19.—BRIDGE SITE OVER THE YELLOWSTONE. LOOKING DOWN.

FIG. 20.—PRESENT BRIDGE OVER LAMAR RIVER. LOOKING DOWNSTREAM.

FIG. 21.—PRESENT BRIDGE OVER LAMAR RIVER. LOOKING UPSTREAM.

FIG. 22.—FORD OVER LEWIS RIVER, ON SNAKE RIVER ROAD. BRIDGE REQUIRED AT THIS POINT.

FIG. 23.—UNITED STATES ENGINEER OFFICE, MAMMOTH HOT SPRINGS, WYO.

APPENDIX K K K.

RECONNAISSANCES, EXPLORATIONS, AND WORK IN THE FIELD, IN MILITARY DIVISIONS AND DEPARTMENTS.

K K K 1.

RECONNAISSANCES, EXPLORATIONS, ETC., IN THE DIVISION OF THE PHILIPPINES.

ANNUAL REPORT OF CAPT. JOHN BIDDLE, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1900.

HEADQUARTERS, DIVISION OF THE PHILIPPINES,
OFFICE, CHIEF ENGINEER OF THE DIVISION,
Manila, P. I., July 12, 1900.

GENERAL: In accordance with instructions dated May 19, 1900, I have the honor to submit the following report of the operations under allotment of funds from your office for the fiscal year 1900.

The funds were as follows:

CIVILIAN ASSISTANTS TO ENGINEER OFFICERS, 1900.

Amount allotted during the fiscal year	$8,000.00
Amount expended during the fiscal year	6,459.32
Turned into subtreasury at San Francisco, Cal	1,540.68

EQUIPMENT OF ENGINEER TROOPS, 1900.

Amount allotted during the fiscal year	$5,000.00
Amount expended during the fiscal year	3,073.72
Turned into subtreasury at San Francisco, Cal	1,926.28

The officers in charge of the Engineer Department at these headquarters have been Lieut. Col. Charles L. Potter, Chief Engineer, U. S. Volunteers, Captain, Corps of Engineers, U. S. A., from June 30, 1899, to September 15, 1899; Capt. William L. Sibert, Corps of Engineers, U. S. A., to November 25, 1899. From the latter date until end of fiscal year 1900 I have been in charge.

There have been on duty in this office the following officers:

First Lieut. S. A. Cheney, Corps of Engineers, U. S. A., from January 2, 1900, to June 30, 1900, with short intervals of service with engineer company.

First Lieut. F. W. Altstaetter, Corps of Engineers, U. S. A., from June 15, 1900, to June 30, 1900.

Capt. C. F. O'Keefe, Thirty-sixth Infantry, U. S. V., all of the year as photographer.

At the headquarters at Iloilo, Panay, now the department of the Visayas, Lieut. R. H. Van Deman, Twenty-first Infantry, U. S. A., has been acting engineer officer, and has made good progress with the map work.

At the headquarters at Zamboanga, now the department of Mindanao and Jolo, the engineer work up to the time of the establishment of the department was under charge of Capt. C. B. Hagadorn, Twenty-third Infantry, U. S. A., who organized and started a very complete system of gathering information about that almost unknown country.

First Lieut. F. W. Kobbé, Twenty-third Infantry, U. S. A., is now acting engineer officer.

The funds for civilian assistants to engineer officers have been expended for hire of employees in the office and field.

The funds for equipment of engineer troops have been expended for purchase and repair of tools and materials for bridge and road work, instruments for reconnaissances and surveying, supplies for drafting and duplicating maps, photography, etc.

A considerable stock of material was on hand at the beginning of the fiscal year, and extra supplies have been sent out from Engineer Depot at Willets Point.

The climate here is very hard on all material, particularly that used in photography and map printing. Everything should be packed in small sealed packages, so as not to be opened until needed.

The blue-print paper sent from Willets Point in sealed cases has proved perfectly satisfactory and has kept well. It is, as far as I can learn, the only blue-print paper ever sent to this part of the world that has kept. Both here and in Hongkong it has been considered impossible to preserve it, and what I have been obliged to buy here has been very poor.

The drawing and surveying instruments rust rapidly. The prismatic compass has not shown itself very satisfactory for field work, as it seems to warp and then act unevenly. The box compass is preferable.

OFFICE AND MAP WORK.

The office work has been the regular routine—the issue of material, tools, and instruments, the drawing and distribution of a large number of maps.

All Spanish maps available have been combined, traced, and printed. These maps, generally speaking and considering the undeveloped nature of the country, have been fairly accurate. The Spanish road maps, covering certain military expeditions, have proved accurate and full of detail, except that the roads and bridges, having been neglected for some years, are in worse condition than the maps would indicate.

It has, therefore, been possible to furnish in advance to all expeditions maps of considerable value.

The expedition to China was also supplied with blue prints.

On the different expeditions of the United States troops road maps have been made, and since the general garrisoning of the islands a complete reconnaissance of the country has been ordered and is being carried out by the officers and men of the command.

Instruments and material are furnished from this office.

These maps are plotted at a scale of 2 inches or 3 inches to the mile and reduced in the headquarters to one inch to the mile.

It is intended eventually to obtain a military map on this scale to cover the whole archipelago, but so divided that any part can be completed independently. This work is only in the initiatory stage.

Maps of military expeditions and engagements, of military departments and districts, of towns, harbors, buildings, etc., have been distributed, with the assistance generally of officers of the commands, and also of the enlisted men of the engineer companies.

The distribution of maps has been extensive and important. Practically everything has been blue-printed.

Since December 1, 1899, from which date a list of maps distributed has been kept, about 4,500 blue prints have left this office, embracing a few more than 200 different maps of various sizes.

A blank form has further been prepared in this office and sent out to the different garrisons for collecting information on general subjects. These will be combined in this office.

The photographic work, of which a large part was done by the men of the engineer companies, has consisted in views of engineer work done in the field and on the railroad—views of forts, of landscapes, etc. Copies have been sent to your office.

FIELD WORK.

On all expeditions in which they have taken part, the engineer troops have been supplied from the depot with tools and material for road, bridge, and ferry building.

The principal detachments sent out were:

Detachment of 40 to 75 men, Company B, under First Lieut. J. C. Oakes, Corps of Engineers, U. S. A., with General Lawton's column in the fall of 1899.

Detachment of 25 to 30 men, Company A, under Second Lieut. W. P. Wooten, Corps of Engineers, U. S. A., with General MacArthur's column during fall of 1899.

Detachment of 30 men from Company A, with First Lieut. S. A. Cheney, Corps of Engineers, U. S. A., and Second Lieut. H. W. Stickle, Corps of Engineers, U. S. A., with General Wheaton's column around San Fabian November and December, 1899.

Detachment from Company B, under Capt. William L. Sibert, Corps of Engineers, U. S. A., on General Schwan's expedition into Cavite Province October, 1899.

Detachment under Captain Sibert with General Schwan, and one under Lieutenant Oakes with General Wheaton, including about all the officers and men on duty with the companies on expedition of General Bates in the southern provinces during January and February, 1900.

Detachment of 50 men from both companies, under First Lieut. H. B. Ferguson, Corps of Engineers, U. S. A., with General Bates's expedition to the Camarines.

Detachment of 20 men from Company B, under Lieutenant Ferguson, with the first expedition to China.

In addition, on various occasions, officers and men have accompanied expeditions as topographers.

A great deal of work, both during the advance and since occupation, was done on the Manila and Dagupan Railroad. This included the rebuilding of trestles and bridges (one of which was over 300 feet long

and about 40 feet high), the relaying of many miles of ties and track, the building of embankment for over a kilometer, carried away by the floods, the placing on track, repairing and operating plant.

The work was done mostly by Lieutenant Ferguson and Lieutenant Wooten with engineer troops, under the supervision of the engineer officer of the department.

Extra tools, principally picks and shovels, were sent with engineer detachments for use of other troops, and in several expeditions on which there were no engineer soldiers, tools, instruments, and material were sent out.

Since the occupation of Luzon, tools have been furnished to the engineer and other troops, as far as the material on hand allowed, to build military bridges and ferries and repair roads.

This work was undertaken too late in the dry season to accomplish much in the way of permanent results.

Several hundred miles of road have been worked more or less, and a dozen or so bridges built and many repaired. This has been done in great part by officers and men detailed from the different regiments, from appropriations out of insular funds.

The work of the engineer companies since the organization of the Division of the Philippines has been almost entirely in connection with road repair and bridge building.

Company A, under Lieutenant Stickle, is attached to the Department of Northern Luzon, and Company B, under Lieutenant Oakes, to the Department of Southern Luzon.

GENERAL REMARKS.

The work done by the two engineer companies has been excellent throughout the year.

The lack of numbers has proved a great disadvantage. This was especially the case in the movements in central Luzon, under Generals Lawton, MacArthur, and Wheaton. The first two columns should, in my opinion, have had from two to four companies with full complement of officers, instead of which there were only detachments of some 50 men with one officer. The consequence was that they were overworked, and even with occasional help of infantry troops could not do all that should have been done.

In the southern expeditions the difficulties were not so great, and the lack of men not so serious.

At the present time there are still too few engineer troops for an army of 60,000 men, and it has not, for example, been possible to send any to the Department of the Viscayas, where they are needed. The lack of officers is also a disadvantage. The plant in stock—instruments, tools, and material—has practically all been of use.

The advance guard ponton train has not been used, except the chess. By the time it arrived here the rivers most adapted for canvas pontons had been crossed, and it was found easier to construct ferries, usually bamboo rafts. The white ants make it difficult to keep train in shape.

A certain amount of work in connection with the harbor and public works has been done under these funds, though generally there have been special appropriations for the purpose.

Examinations have been made by engineer officers of the existing

forts at Jolo and Manila, and reports, maps, and photographs have been sent to your office.

It has not been practicable up to this date to have examination made of any other fortified points.

Very respectfully,

JOHN BIDDLE,
Captain, Corps of Engineers, U. S. A.,
Chief Engineer of the Division.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

K K K 2.

ENGINEERING OPERATIONS IN THE DEPARTMENT OF PORTO RICO.

ANNUAL REPORT OF CAPT. WILLIAM V. JUDSON, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1900.

UNITED STATES ENGINEER OFFICE,
DEPARTMENT OF PORTO RICO,
San Juan, P. R., July 20, 1900.

GENERAL: I have the honor to report as follows upon the operations of this office during the fiscal year 1899–1900, under the following allotments, viz:

Civilian Assistants to Engineer Officers, 1900	$2,385.00
Equipment of Engineer Troops, 1900	500.00
Total	2,885.00

First Lieut. Samuel G. Jones, Fifth Cavalry, U. S. A., was acting engineer officer of the department until relieved by the undersigned, August 27, 1899.

During the incumbency of Lieutenant Jones the duties of the office involved the preparation of various reports upon land matters; the care of engineer property; the issue, when required, to officers of instruments, drawing materials, etc., and the prosecution of dredging operations, wharf policing, and repairs, and equipment of machine shop, all at San Juan Harbor, Porto Rico. Insular appropriations furnished the chief means for the prosecution of the harbor work last mentioned.

During the incumbency of the undersigned his duty up to May 1, 1900, embraced that of president of the board of public works of Porto Rico, this board being engaged in work involving insular expenditures; while as engineer officer of the department he has had immediate charge of the disbursement of $950,000 of moneys appropriated by Congress and devoted to the construction of roads, etc., in Porto Rico, to relieve its people who were suffering from starvation and sickness incident to the hurricane of August 8, 1899.

In the case of the above duties, the appropriations being expended furnished funds for supervision.

In addition to the above, several military reservations were surveyed, or titles thereto investigated. Maps were prepared showing the lands on San Juan Island of public ownership. This work has been only tentatively completed, as titles and descriptions are very defective in

most of these cases. A start has been made upon a topographical map of Porto Rico. This work has not been pushed, partly for lack of time and partly because the road surveys and coast survey data will soon be available, and should be embodied in any new map.

Harbor lines at San Juan Harbor have been recommended for adoption to the Secretary of War.

The construction of a pier at this harbor, under revocable license issued to the New York and Porto Rico Steamship Company, has been supervised, and data procured for report of cost to the Secretary of War.

Many reports have been submitted upon matters relating to franchises and concessions in Porto Rico, and many reports on various engineering subjects have been prepared for the department commander.

The engineer property has been cared for, and, upon request, officers serving in the department have been furnished instruments and materials.

Money statements.

CIVILIAN ASSISTANTS TO ENGINEER OFFICERS, 1900.

June 30, 1900, amount allotted during fiscal year	$2,385.00
June 30, 1900, amount expended during fiscal year	2,385.00

EQUIPMENT OF ENGINEER TROOPS, 1900.

June 30, 1900, amount allotted during fiscal year	$500.00
June 30, 1900, amount expended during fiscal year	500.00

Respectfully submitted.

W. V. JUDSON,
Captain, Corps of Engineers,
Engineer Officer of the Department.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

K K K 3.

EXPLORATIONS AND SURVEYS IN THE DEPARTMENT OF THE COLUMBIA.

REPORT OF CAPT. HENRY P. M'CAIN, FOURTEENTH INFANTRY, FOR THE FISCAL YEAR ENDING JUNE 30, 1900.

ENGINEER OFFICE,
HEADQUARTERS, DEPARTMENT OF THE COLUMBIA,
Vancouver Barracks, Wash., July 7, 1900.

GENERAL: I have the honor to submit the following report of the operations of the engineer office, Department of the Columbia, for the year ending June 30, 1900:

FIELD WORK.

Instrumental surveys for extensions to the water and sewerage systems, and the laying out of the camps and buildings necessary for the

accommodation of the different volunteer organizations ordered to rendezvous at Vancouver Barracks, Wash., and the supervision of the construction of same.

OFFICE WORK.

The preparation of maps, plans, etc., as follows:

Plans, profiles, and specifications for extensions to water and sewerage systems at Vancouver Barracks, Wash.

Detail plans of volunteer camps at Vancouver Barracks, Wash.

Plan of post of Vancouver Barracks, showing camps of volunteers.

Tracing of map of trail from Port Valdez to Fort Egbert, Alaska.

Tracing of maps of proposed military reservation at Fort Egbert, Alaska.

Tracing of map of Fort Kodiak, Alaska.

Tracing of map of proposed military reservation at Skagway, Alaska.

Plan of Vancouver Barracks, with new system of numbering.

Plan and specification of 75-foot flagstaff.

Plan of Fort Spokane, Wash., with water and sewerage systems, for Department of the Interior.

Collecting and compiling data for Department maps.

Photographic work of Alaska Exploring Expedition of 1899, under command of Capt. E. F. Glenn, Twenty-fifth Infantry.

Forty-five solar prints made.

Two hundred and twenty-two silver prints made.

Sixteen maps mounted on muslin.

Very respectfully,

HENRY P. MCCAIN,
Captain, Fourteenth Infantry,
Engineer Officer.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

K K K 4.

EXPLORATIONS AND SURVEYS IN THE DEPARTMENT OF THE COLORADO.

REPORT OF CAPT. JOHN B. BENNET, SIXTEENTH INFANTRY, FOR THE FISCAL YEAR ENDING JUNE 30, 1900.

ENGINEER OFFICE,
HEADQUARTERS, DEPARTMENT OF THE COLORADO,
Denver, Colo., July 6, 1900.

GENERAL: I have the honor to submit the following report of this office for the fiscal year ending June 30, 1900:

PERSONNEL.

Capt. J. B. Bennet, U. S. A., engineer officer of the department by virtue of paragraph 4, General Orders 3, Department of the Colorado, 1899, continued in charge of the office during the year.

From June 30, 1899, to May 1, 1900, this office was without clerical assistance.

On May 1, 1900, Mr. W. P. Pierson was assigned as clerk, and was on duty the remainder of the year.

OFFICE WORK.

Office work during the past year has been confined to making a number of tracings and blue prints of official maps on file, and to caring for engineer property in the office and issued to post engineer officers.

No field work has been done during the year other than sketches of practice marches and field exercises.

Very respectfully,

JNO. B. BENNET,
Captain, Sixteenth Infantry,
Acting Engineer Officer.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

APPENDIX L L L.

CONSTRUCTION OF MILITARY ROAD FROM FORT WASHAKIE TO MOUTH OF BUFFALO FORK OF SNAKE RIVER, WYOMING.

REPORT OF CAPT. H. M. CHITTENDEN, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1900.

UNITED STATES ENGINEER OFFICE,
Sioux City, Iowa, July 2, 1900.

GENERAL: I have the honor to transmit herewith report upon military road from Fort Washakie, Wyo., to mouth of Buffalo Fork of Snake River for the fiscal year ending June 30, 1900.

Very respectfully, your obedient servant,

H. M. CHITTENDEN,
Captain, Corps of Engineers, U. S. A.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

REPORT ON CONSTRUCTION OF MILITARY ROAD FROM FORT WASHAKIE TO MOUTH OF BUFFALO FORK OF SNAKE RIVER, WYOMING.

Description of the locality, character, and value of the road, and work done to June 30, 1899, are described in the Annual Report of the Chief of Engineers, 1899, Part 6, pages 3881–3900.

The sundry civil appropriation act of June 6, 1900, provided for further road work as follows:

Military road, Wyoming: For the repair, construction, and completion of the military road from Fort Washakie to near Jacksons Lake, in Uinta County, Wyoming, authorized by provision in the sundry civil appropriation act approved June fourth, eighteen hundred and ninety-seven, ten thousand dollars.

A project for expenditure of the above was approved June 22, 1900, and preparations were made for commencing the work. There have been no field operations during the year.

Amount expended to June 30, 1899, $9,832.32.

Amount expended during fiscal year ending June 30, 1900, $142.56.

For map of the locality see House Doc. No. 245, Fifty-fifth Congress, third session.

Money statement.

July 1, 1899, balance unexpended	$167.68
Act of June 6, 1900	10,000.00
	10,167.68
June 30, 1900, amount expended during fiscal year	142.56
July 1, 1900, balance unexpended	10,025.12
July 1, 1900, outstanding liabilities	6.73
July 1, 1900, balance available	10,018.39

APPENDIX M M M.

ERECTION OF A MONUMENT TO SERGEANT CHARLES FLOYD.

REPORT OF CAPT. H. M. CHITTENDEN, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1900.

UNITED STATES ENGINEER OFFICE,
Sioux City, Iowa, July 2, 1900.

GENERAL: I have the honor to submit the following report of operations during the fiscal year ending June 30, 1900, on the erection of a monument to Sergt. Charles Floyd:

The deficiency act of March 3, 1899, contains the following item of appropriation:

Monument to Sergeant Charles Floyd: To enable the Secretary of War, in cooperation with the Floyd Memorial Association, to cause to be erected over the remains of Sergeant Charles Floyd, a member of the Lewis and Clark expedition, who died and was buried August twentieth, eighteen hundred and four, near the present site of Sioux City, Iowa, a fitting monument commemorative of that expedition and of the first soldier to lay down his life within the Louisiana Purchase, five thousand dollars: *Provided*, That the total cost and expense to the United States of erecting said monument shall not exceed five thousand dollars.

During the fiscal year definite progress has been made toward the early completion of this work. On May 5, 1900, the Secretary of War approved a project embodying a general design and method of procedure in erecting the monument in cooperation with the State of Iowa, which had also given $5,000 in aid of the work (act of the State legislature approved April 7, 1900).

The foundation, consisting of a solid monolithic mass of concrete, was put in on the 28th of May. It is in the form of a frustum of a pyramid, 22 feet square at the base, 13 feet 6 inches square at the top, and 11 feet high.

On the 31st of May bids were opened for the stone for the superstructure, and on June 26 a contract was entered into on the part of the State of Iowa with the Minnesota Sandstone Company, of Minneapolis, Minn., for furnishing the stone for the superstructure. The Kettle River Sandstone was adopted.

Proposals are being advertised for the work of erection, and it is expected to lay the corner stone of the monument August 20, the anniversary of the death of Sergeant Floyd, and to complete the work before the end of October.

The style of monument selected is the Egyptian obelisk. Its height will be 100 feet, 3¼ inches.

The details of the work will be deferred for the final report, which will be prepared after the completion of the monument.

Money statement.

July 1, 1899, balance unexpended	$5,000.00
June 30, 1900, amount expended during fiscal year	1,327.17
July 1, 1900, balance unexpended	3,672.83
July 1, 1900, outstanding liabilities	81.14
July 1, 1900, balance available	3,591.69

Very respectfully, your obedient servant,

H. M. CHITTENDEN,
Captain, Corps of Engineers, U. S. A.

Brig. Gen. JOHN M. WILSON,
Chief of Engineers, U. S. A.

LAWS

AFFECTING

THE CORPS OF ENGINEERS,

UNITED STATES ARMY,

FIFTY-SIXTH CONGRESS, FIRST SESSION.

1899-1900.

LAWS

AFFECTING

THE CORPS OF ENGINEERS, UNITED STATES ARMY.

FIFTY-SIXTH CONGRESS, FIRST SESSION, 1899–1900.

PUBLIC ACTS.

CHAP. 1.—An Act To extend the time for examination of monthly accounts by bureaus and offices of the War Department.

December 20, 1899.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the time for examination of monthly accounts by the bureaus and offices of the War Department after the date of actual receipt and before transmitting the same to the Auditor for the War Department, as limited by section twelve of the legislative, executive, and judicial appropriation Act, approved July thirty-first, eighteen hundred and ninety-four, is hereby extended from twenty days to sixty days for the period of one year from the date of the passage of this Act.

War Department.
Examination of monthly accounts; time extended.

Vol. 28, p. 209.

Approved, December 20, 1899.

CHAP. 3.—An Act Extending the time for the completion of a wagon and motor bridge across the Missouri River at Saint Charles, Missouri, as provided by an Act approved June third, eighteen hundred and ninety-six.

January 27, 1900.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the time for completing the construction of a wagon and motor bridge across the Missouri River at Saint Charles, Missouri, as fixed by an Act approved June third, eighteen hundred and ninety-six, be extended to June third, nineteen hundred and two.

Time extended for bridging Missouri River at St. Charles.
Vol. 29, p. 195.

Approved, January 27, 1900.

CHAP. 14.—An Act Making appropriations to supply urgent deficiencies in the appropriations for the fiscal year ending June thirtieth, nineteen hundred, and for prior years, and for other purposes.

February 9, 1900.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums be, and the same are hereby, appropriated, out of any money in the Treasury not otherwise appropriated, to supply deficiencies in the appropriations for the fiscal year nineteen hundred, and for prior years, and for other objects hereinafter stated, namely:

Deficiencies appropriations.

*   *   *   *   *

War Department.

WAR DEPARTMENT.

* * * * *

Additional temporary force.

For continuing the employment during the three months beginning April first, nineteen hundred, of such additional temporary force of clerks, messengers, laborers, and other assistants as in the judgment of the Secretary of War may be proper and necessary to the prompt, efficient, and accurate dispatch of official business in the War Department and its bureaus, to be alloted by the Secretary of War to such bureaus and offices as the exigencies of the needs of the service may demand, one hundred and fifty thousand dollars. Persons in the classified service of the Government shall not be eligible to appointment under this appropriation, or to be transferred from any position in the classified service to positions paid hereunder.

Classified service ineligible for appointment, etc.

* * * * *

Miscellaneous.

MISCELLANEOUS OBJECTS, WAR DEPARTMENT.

Deep Waterways Commission.

DEEP WATERWAYS COMMISSION: For completing surveys, examinations, and investigations (including estimate of cost) of deep waterways, and the routes thereof, between the Great Lakes and the Atlantic tide waters, as recommended by the report of the Deep Waterways Commission, transmitted by the President to Congress January eighteenth, eighteen hundred and ninety-seven; such surveys, examinations, and investigations to be made by the board of three engineers designated and appointed by the President for this purpose July twenty-eighth, eighteen hundred and ninety-seven, in compliance with the provisions of the Act of June fourth, eighteen hundred and ninety-seven, twenty thousand dollars: *Provided*, That the member of the Deep Waterways Commission appointed from the Corps of Engineers shall be entitled to receive compensation from the date of his appointment, in addition to his regular army pay and allowances, equal to the difference between such annual army pay and allowances and the compensation of the other two members of the commission, said additional compensation to be paid from funds appropriated for the Deep Waterways Commission.

Vol. 30, p. 50.

Proviso.

Compensation of member from Engineer Corps.

* * * * *

Approved, February 9, 1900.

February 15, 1900.

CHAP. 21.—An Act To authorize the Southeastern Railroad Company to construct and maintain a bridge across the Lumber River within the boundary lines of Robeson County, North Carolina.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Southeastern Railroad Company, a corporation created and existing under an act of the general assembly of the State of North Carolina, be, and is hereby, authorized to construct and maintain a railroad bridge for the passage of railway engines and cars across the Lumber River, at such point as may be selected by such company and approved by the Secretary of War within the boundary lines of Robeson County, North Carolina, said bridge to be so constructed as not to obstruct the

Southeastern Railroad may bridge Lumber River, N. C.

—location, etc.

navigation of said river, and to be provided with a suitable draw: *Provided*, That any bridge constructed under this Act and according to its limitations shall be a lawful structure, and shall be known and recognized as a post route, and the same is hereby declared to be a post route, and the United States shall have the right of way for a postal telegraph across said bridge.

Proviso. Lawful structure and post route.

SEC. 2. That the bridge authorized to be constructed under this Act shall be located and built under and subject to such regulations for the security of the navigation of said river as the Secretary of War shall prescribe; and the said company or corporation shall submit to the Secretary of War, for his examination and approval, a design and drawing of the proposed bridge and a map of the location, giving, for the space of one-fourth of a mile above and one-fourth of a mile below the proposed location, the topography of the banks of the river, the shore lines at high and low water, the direction and strength of the currents, and the soundings, accurately showing the bed of the stream, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until the said plan and location of the bridge are approved by the Secretary of War no work upon the bridge shall be commenced; and should any change be made in the plan of said bridge during the progress of construction, such change shall be subject to the approval of the Secretary of War.

Secretary of War to approve plans, etc.

SEC. 3. That Congress reserves the right to alter, amend, or repeal this Act at any time; and that if at any time navigation of said river shall in any manner be obstructed or impaired by the said bridge the Secretary of War shall have authority, and it shall be his duty, to require the said bridge company to alter and change the said bridge, at its own expense, in such manner as may be proper to secure free and complete navigation without impediment.

Amendment; changes, etc.

SEC. 4. That the draw provided for the bridge herein authorized to be constructed shall be opened promptly, upon reasonable signal, for the passing of boats, which said company or corporation shall maintain, at its own expense; and if actual construction of the bridge herein authorized shall not be commenced within one year from the passage of this Act and be completed within three years from same date, the rights and privileges hereby granted shall cease and be determined.

Draw.

Commencement and completion.

Approved, February 15, 1900.

CHAP. 23.—An Act To amend "An Act making appropriations for the construction, repair, and preservation of certain public works on rivers and harbors, and for other purposes," approved March third, eighteen hundred and ninety-nine.

February 20, 1900.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That section one of the Act entitled "An Act making appropriations for the construction, repair, and preservation of certain public works on rivers and harbors, and for other purposes," approved March third, eighteen hun-

Galveston Ship Channel and Buffalo Bayou, Texas, improvement of.

dred and ninety-nine, be, and the same is hereby, amended by striking out and repealing the paragraphs in said Act on pages eleven hundred and twenty-seven and eleven hundred and twenty-eight of the United States Statutes at Large, volume thirty, which reads as follows:

Repeal of paragraphs in prior act.

Vol. 30, pp. 1127, 1128.

Improving Galveston Ship Channel and Buffalo Bayou, Texas: For improvement of the Galveston Ship Channel and Buffalo Bayou, by dredging or otherwise, from the jetties at Galveston, Texas, up through the present ship channel and Buffalo Bayou to the proposed harbor site at Houston, Texas, to be provided by the citizens of Houston, three hundred thousand dollars: *Provided*, That out of said sum a suitable dredge may be constructed for said work.

For commencing the improvement of the water route from the mouth of the jetties at Galveston, through the existing ship channel and up Buffalo Bayou to Houston, Texas, including harbor at Houston, in accordance with project submitted by the Board of Engineers in report of survey dated November third, eighteen hundred and ninety-seven, two hundred and fifty thousand dollars: *Provided*, That contracts may be entered into by the Secretary of War for the whole or any part of such materials and work as may be required for prosecuting said improvement, or the said materials may be purchased and the work done otherwise than by contract, to be paid for as appropriations may from time to time be made by law, not to exceed in the aggregate two million dollars: *Provided further*, That out of said sum two dredges may be constructed for said work.

And amend said Act so as to read in place of said paragraphs repealed as follows:

Act amended.

"Improving Galveston Ship Channel and Buffalo Bayou, Texas: For improvement of the Galveston Ship Channel and Buffalo Bayou, by dredging or otherwise in accordance with the project submitted by a board of engineers in the report of a survey dated November third, eighteen hundred and ninety-seven, and submitted by the Chief of Engineers in his report for eighteen hundred and ninety-eight, in volume one, pages two hundred and eighty-eight and two hundred and eighty-nine, three hundred thousand dollars: *Provided*, That all sums heretofore appropriated and available for work on Galveston Ship Channel and Buffalo Bayou are hereby made available for said project: *Provided further*, That all of said sums of money not necessary for administration, surveys, and maintenance be used in improving division one of said survey."

Provisos.

Prior appropriations available.

Division one of survey.

SEC. 2. That section twelve of the same act be, and the same is hereby, amended by striking out the word "fourteen," after the word "section," and inserting in lieu thereof the word "eleven."

SEC. 3. That section twenty of the same act be, and the same is hereby, amended by striking out the word "ten," after the word "sections," and inserting in lieu thereof the word "nine."

Approved, February 20, 1900.

CHAP. 24.—An Act To amend an Act entitled "An Act to amend an Act to suspend the operation of certain provisions of law relating to the War Department, and for other purposes."

February 24, 1900.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That an Act entitled "An Act to amend an Act entitled 'An Act to suspend the operation of certain provisions of law relating to the War Department, and for other purposes,'" approved March third, eighteen hundred and ninety-nine, is hereby amended so as to read as follows:

Army.
Suspension of certain provisions of law. Vol. 30, p. 1350.

"That the operation of the following provisions of law be, and is hereby, continued suspended for such further time as, in the discretion of the Secretary of War, may be found necessary, or until otherwise provided by Congress, not longer, however, than June thirtieth, nineteen hundred and one:

*   *   *   *   *

SEC. 2. That during the time the operation of the foregoing provisions of law shall remain so suspended pursuant to this Act, materials required by the War Department may, in the discretion of the Secretary of War, be purchased abroad and shall be admitted free of duty.

Admission free of duty of war materials.

*   *   *   *   *

Approved, February 24, 1900.

CHAP. 26.—An Act To amend an Act entitled "An Act to authorize the Grand Rapids Water Power and Boom Company, of Grand Rapids, Minnesota, to construct a dam and bridge across the Mississippi River," approved February twenty-seventh, eighteen hundred and ninety-nine.

February 27, 1900.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That section three of an Act entitled "An Act to authorize the Grand Rapids Water Power and Boom Company, of Grand Rapids, Minnesota, to construct a dam and bridge across the Mississippi River," approved February twenty-seventh, eighteen hundred and ninety-nine, is hereby amended so as to read as follows:

Time extended to Grand Rapids Water Power and Boom Company to dam, etc., Mississippi River at Grand Rapids, Minn.

"SEC. 3. That this Act shall be null and void unless said dam herein authorized be commenced within two years and completed within four years from the date hereof."

Approved, February 27, 1900.

CHAP. 27. An Act To authorize the construction of a bridge across the Red River of the North, at Drayton, North Dakota.

February 28, 1900.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the council of the city of Drayton, county of Pembina, State of North Dakota, be, and are hereby, authorized to construct and maintain a pontoon bridge and approaches thereto across the Red River of the North,

Drayton, N. Dak., may bridge Red River of the North at Drayton.

between the State of North Dakota and the State of Minnesota, extending from the foot of Almeron or Grant streets in said town of Drayton to a point opposite, in the State of Minnesota. Said bridge shall be constructed so as to provide for the passage of wagons and vehicles of all kinds, animals, and foot passengers, and for all road travel, for such reasonable rates of toll and under such rules and regulations as may be prescribed by said council and approved from time to time by the Secretary of War.

Transit, toll, etc.

To be lawful structure and post route.

SEC. 2. That any bridge built under this Act and subject to its limitations shall be a lawful structure and shall be recognized and known as a post route, upon which also no higher charge shall be made for the transmission over the same of the mails, the troops, and the munitions of war of the United States than is charged other parties for like privileges; and it shall enjoy the rights and privileges of other post roads in the United States, and the United States shall have the right of way across said bridge and its approaches for postal-telegraph purposes. And equal rights as to constructing and maintaining their lines over said bridge shall be granted to all telephone and telegraph companies desiring to use the same.

Telephone, etc., companies.

Draw, etc.

SEC. 3. That said bridge shall be constructed as a pontoon drawspan bridge, and shall contain a pontoon drawspan of such dimensions as the Secretary of War shall prescribe, which said drawspan shall be maintained on the main channel of the river at an accessible and navigable point; and the piers of said bridge shall be parallel with, and the bridge itself at right angles to, the current of the river: *Provided*, That said draw shall be opened promptly, upon reasonable signal, for the passage of boats and rafts; and said council of the city of Drayton shall maintain, at the expense of the said city, from sunset to sunrise, such lights or other signals on said bridge as the Light-House Board shall prescribe. No bridge shall be constructed or maintained under the authority of this Act which shall at any time substantially or materially obstruct the free navigation of said river; and if any bridge erected under said authority shall, in the opinion of the Secretary of War, obstruct such navigation, he is hereby authorized to cause such change or alteration of said bridge to be made as will effectually obviate such obstruction, and all such alterations shall be made and all such obstructions be removed at the expense of the said city of Drayton; and in case of any litigation arising from any obstruction or alleged obstruction to the free navigation of said river, caused or alleged to be caused by said bridge, suit may be brought in any circuit court of the United States for the circuit in which said bridge or any part thoreof is located to remove or remedy the same: *Provided further*, That nothing in this Act shall be so construed as to repeal or modify any of the provisions of law now existing in reference to the protection of the navigation of rivers, or to exempt this bridge from the operations of the same.

Provisos.
—opening of.

Lights.

Not to obstruct navigation.

—litigation.

Existing law unaffected.

SEC. 4. That any bridge authorized to be constructed under this Act shall be built and located under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe; and to secure that object the said city or council shall submit to the Secretary of War, for his examination and approval, a design and drawings of the said bridge, and a map of the location, giving, for the space of one-half mile above and one-half mile below the proposed location, the high and low water lines upon the banks of the river, the direction and strength of the currents at all stages, with the soundings accurately showing the bed of the stream, and the location of any other bridge or bridges, such map to be sufficiently in detail to enable the Secretary of War to judge of the proper location of said bridge, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until such plan and location of the bridge are approved by the Secretary of War the bridge shall not be built; and should any change be made in the plan of said bridge during the progress of construction or after completion, such change shall be subject to the approval of the Secretary of War. Secretary of War to approve plans, changes, etc.

SEC. 5. That the right to alter, amend, or repeal this Act is hereby expressly reserved. Amendment.

SEC. 6. That this Act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year and completed within three years from the date of the approval of this Act. Commencement and completion.

Approved, February 28, 1900.

CHAP. 29.—An Act To authorize Frank Hitch to construct and maintain a bridge across Fishing Creek within the boundary lines of Edgecombe County, North Carolina. March 1, 1900.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That Frank Hitch be, and is hereby, authorized to construct and maintain a railroad bridge for the passage of railway engines and cars across Fishing Creek at such point as may be selected by said Hitch and approved by the Secretary of War within the boundary lines of Edgecombe County, North Carolina, said bridge to be so constructed as not to obstruct the navigation of said river, and to be provided with a suitable draw: *Provided*, That any bridge constructed under this Act and according to its limitations shall be a lawful structure, and shall be known and recognized as a post route, and the same is hereby declared to be a post route, and the United States shall have the right of way for a postal telegraph across said bridge. Frank Hitch may bridge Fishing Creek, Edgecombe County, N.C. *Proviso.* To be lawful structure, etc.

SEC. 2. That the bridge authorized to be constructed under this Act shall be located and built under and subject to such regulations for the security of the navigation of said creek as the Secretary of War shall prescribe; and Secretary of War to approve plans, changes, etc.

the said Hitch shall submit to the Secretary of War, for his examination and approval, a design and drawing of the proposed bridge and a map of the location, giving, for the space of one-fourth of a mile above and one-fourth of a mile below the proposed location, the topography of the banks of the river, the shore lines at high and low water, the direction and strength of the currents, and the soundings, accurately showing the bed of the stream, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until the said plan and location of the bridge are approved by the Secretary of War no work upon the bridge shall be commenced; and should any change be made in the plan of said bridge during the progress of construction, such change shall be subject to the approval of the Secretary of War.

Amendment.

SEC. 3. That Congress reserves the right to alter, amend, or repeal this Act at any time; and that if at any time navigation of said creek shall in any manner be obstructed or impaired by the said bridge, the Secretary of War shall have authority, and it shall be his duty, to require the said bridge company to alter and change the said bridge, at its own expense, in such manner as may be proper to secure free and complete navigation without impediment.

Obstruction to navigation.

Draw.

SEC. 4. That the draw provided for the bridge herein authorized to be constructed shall be opened promptly, upon reasonable signal, for the passing of boats, which said Hitch shall maintain at his own expense; and if actual construction of the bridge herein authorized shall not be commenced within one year from the passage of this Act and be completed within three years from same date, the rights and privileges hereby granted shall cease and be determined.

Commencement and completion.

Approved, March 1, 1900.

March 1, 1900.

CHAP. 30.—An Act To authorize the Natchitoches Railway and Construction Company to build and maintain a railway and traffic bridge across Red River at Grand Ecore, in the parish of Natchitoches, State of Louisiana.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Natchitoches Railway and Construction Company, a corporation duly incorporated and existing under and by virtue of the laws of the State of Louisiana, be, and is hereby, authorized to construct and maintain, by itself or through its assignees, a railway and traffic bridge across Red River at a point suitable to the interest of navigation, at Grand Ecore, parish of Natchitoches, State of Louisiana. Said bridge shall be constructed to provide for passage of railway trains, and for all legitimate traffic of foot, horse, vehicle, animal, and all other legitimate purposes, and for transmission of the mails, at such legal

Natchitoches Railway, etc., Company may bridge Red River at Grand Ecore, La.

Transit, toll, etc.

rates of toll as may be fixed by said railway company or its transferees and approved by the Secretary of War, except to the people of the parish of Natchitoches, to whom the use of said bridge shall at all times and under all circumstances be free.

SEC. 2. That said bridge, built under this Act and subject to its limitations, shall be a lawful structure, and shall be recognized and known as a post route, upon which also no higher charge shall be made for the transmission over the same of the mails, the troops, and munitions of war of the United States than the rate per mile paid for the transportation over the railroad or public highways leading to the said bridge, and shall enjoy the rights and privileges of other post roads in the United States; and equal privileges in the use of said bridge shall be granted to all telegraph and telephone companies; and the United States shall have the right of way across said bridge and its approaches for postal telegraph purposes: *Provided*, That the bridge herein authorized to be constructed shall be so kept and managed by the company owning or operating it as to afford proper ways and means for the passage through or under it of vessels, barges, or rafts at all times, both by day and by night. And if said bridge be constructed as a drawbridge, the draw shall be opened promptly upon reasonable signal for the passage of boats; and upon whatever kind of bridge is built there shall be displayed, from sunset to sunrise, at the expense of said company, such lights and signals as the Light-House Board shall prescribe.

To be lawful structure and post route.

Telegraph, etc., companies.

Proviso.
Aids to navigation.

Draw.

Lights.

SEC. 3. That if said bridge, erected and maintained under the authority of this Act, shall at any time substantially or materially obstruct the free navigation of said river, or shall, in the opinion of the Secretary of War, obstruct such navigation, he is hereby authorized to cause such change or alteration of said bridge to be made as will effectually obviate such obstruction; and such alteration shall be made and all such obstructions be removed at the expense of the owner or operators of said bridge; and in case of any litigation arising from the obstruction or alleged obstruction to the free navigation of said river, the case may be brought in the district court of the United States for the western district of Louisiana: *Provided*, That nothing in this Act shall be so construed as to repeal or modify any of the provisions of law now existing in reference to the protection of the navigation of rivers, or to exempt said bridge from the operation of same.

Obstructions to navigation.

—alterations.

—litigation.

Proviso.
Existing law unaffected.

SEC. 4. That all railroad companies desiring to use the said bridge shall have and be entitled to equal rights and privileges relative to the passage of railway trains over the same and the approaches thereto upon the payment of a reasonable compensation for such use, which compensation may be different in case of different railways. In case of disagreement as to compensation for the use of said bridge, the difference shall be determined by the

Right of railroads to use.

Secretary of War upon hearing the allegations and proof of the parties in interest.

Secretary of War to approve plans, etc.

SEC. 5. That the bridge authorized to be constructed under this Act shall be built and located under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe; and to secure that object the said company or corporation shall submit to the Secretary of War, for his examination and approval, a design and drawings of said bridge, and a map of the location, prepared with reference to known datum plane upon prescribed scale, furnished by the engineer officer having supervision of said river, and giving, for the space of two miles above and two miles below the proposed location of the bridge, the topography of the banks of the river, with shore lines at high and low water, the direction and strength of the currents at all stages, and the soundings accurately showing the bed of the stream, the location of any other bridge or bridges, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject. And until the said plans and location of the bridge are approved by the Secretary of War the bridge shall not be built; and should any change be made in the plan of the said bridge during the process of construction such change shall be subject to the approval of the Secretary of War, and said structure shall be changed at the costs and expense of the owners thereof from time to time, as the Secretary of War may direct, so as to preserve the free and convenient navigation of said river.

—changes.

Commencement and completion.

SEC. 6. That this Act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year, and completed within three years from the date hereof.

Amendment.

SEC. 7. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

Approved, March 1, 1900.

March 1, 1900.

CHAP. 31.—An Act Authorizing the construction by the Texarkana, Shreveport and Natchez Railway Company of a bridge across Twelve-mile Bayou near Shreveport, Louisiana.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

Texarkana, Shreveport and Natchez Railway may bridge Twelve-mile Bayou, La.

That the Texarkana, Shreveport and Natchez Railway Company, a railroad corporation duly incorporated under the laws of the State of Louisiana, its successors or assigns, be, and it is hereby, authorized to construct and maintain a railway bridge and approaches thereto over and across Twelve-mile Bayou, in Caddo Parish, Louisiana, at or about eight miles above the point where said bayou empties into Red River. Said bridge shall be constructed to provide for the passage of railway trains and, at the option of said company, may be used for the passage of wagons and vehicles of all kinds, for the passage of animals, and for foot passengers for such reasonable rates

Transit, toll, etc.

of toll as may be approved from time to time by the Secretary of War; that said bridge shall be a drawbridge with a draw over the main channel of the bayou, and said draw shall be opened promptly, upon reasonable signals, for the passing of boats and water crafts; and said company shall maintain, at its own expense, from sunset to sunrise throughout the season of navigation, such lights or other signals on said bridge as the Light-House Board may prescribe.

Draw.

Lights.

SEC. 2. That the bridge herein authorized shall be built and located under and in accordance with such regulations for the security of navigation as the Secretary of War shall prescribe; and to secure that object the said company shall submit to the Secretary of War, for his examination and approval, drawings showing the plan and location of said bridge, said drawings to give, for the space of one-half mile above and one-half mile below the proposed location, the topography of the banks of the river, the shore lines at high and low water, the direction and strength of the current at all stages, and the soundings accurately showing the bed of the stream, and such other information as may be required for a full and satisfactory understanding of the subject; and any change in the plan of said bridge, either before or after construction, shall be subject to the approval of the Secretary of War, and any change in said bridge during or after construction which the Secretary of War may require in the interest of navigation shall be made by the said company at its own expense.

Secretary of War to approve plans, etc.

—changes.

SEC. 3. That no bridge shall be erected or maintained under the authority of this Act which shall at any time substantially or materially obstruct the free navigation of said bayou; and if any bridge erected under such authority shall, in the opinion of the Secretary of War, obstruct such navigation, he is hereby authorized to cause such change or alterations of such bridge to be made as will effectually obviate such obstructions, and all such alterations shall be made, and all such obstructions shall be removed, at the expense of the owner or owners of said bridge.

Not to obstruct navigation.

—alterations.

SEC. 4. That any bridge built under this Act and subject to its limitations shall be a lawful structure, and shall be recognized and known as a post route, upon which no higher charge shall be made for the transmission over the same of mails, the troops, and the munitions of war of the United States than the rate per mile paid for the transportation over the railroad or public highways leading to said bridge, and it shall enjoy all the rights and privileges of other post roads in the United States.

To be lawful structure and post route.

SEC. 5. That all railway companies desiring the use of said bridge shall have and be entitled to equal rights and privileges relative to the passage of railway trains over the same, and over the approaches thereto, upon payment of a reasonable compensation for such use; and in case the owner or owners of said bridge and the several railroad companies, or any of them, desiring such use shall fail to

Right of railroads to use.

agree upon the sum or sums to be paid and upon rules and conditions to which each shall conform in using said bridge all matters at issue between them shall be decided by the Secretary of War, upon a hearing of the allegations and proof of the parties.

Amendment. SEC. 6. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

Completion. SEC. 7. That this Act shall be null and void if the bridge herein authorized be not completed within two years from the approval of this Act.

Approved, March 1, 1900.

March 2, 1900.

CHAP. 33.—An Act To authorize the Union Railroad Company to construct and maintain a bridge across the Monongahela River.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

Union Railroad may bridge Monongahela River, Pa.

That the Union Railroad Company, a corporation existing under the laws of the State of Pennsylvania, is hereby authorized to construct, maintain, and operate a railroad bridge, with single or double track, for railroad traffic across the Monongahela River, within the limits of Allegheny County, State of Pennsylvania, between a point in Mifflin Township and a point opposite in the borough of Rankin. The said bridge, when built in accordance with the requirements of this Act, shall be a legal structure, and may be used for railroad and highway purposes.

Legal structure, etc.

Spans. SEC. 2. That in any bridge built under the provisions of this Act the channel span shall not be less than fifty-three feet above the level of the water at pool full in said river to the bottom chord of the bridge, the north shore span shall be not less than fifty-two feet, and all other spans not less than forty-five feet above the same level, nor shall the main span be less than four hundred and seventy-five feet in length in the clear, and the piers of the bridge shall be parallel with the current of the river, and the main span shall be over the main channel of the river at ordinary water.

Secretary of War to approve plans, etc.

SEC. 3. That the bridge authorized to be constructed under this Act shall be located and built under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe, and to secure that object the railroad company shall submit to the Secretary of War, for his examination and approval, a design and drawing of the bridge and a map of the location, giving, for the space of three-fourths of a mile above and below the proposed location, the depth and currents at all points of the same and the location of any other bridge or bridges, together with all other information touching said bridge and river as may be deemed requisite by the Secretary of War to determine whether said bridge when built will conform to the provisions of this Act and cause any serious obstruction to the navigation of the river or injuriously affect the flow of water.

SEC. 4. That the Secretary of War is hereby authorized and directed, upon receiving said plan and map, and upon being satisfied that a bridge built on such a plan and at said locality will conform to the provisions of this Act and cause no serious obstruction to the navigation of the river or injuriously affect the flow of water, to notify the said company that he approves the same, and upon receiving such notification the said company may proceed to the erection of said bridge, conforming strictly to the approved plan and location. But until the Secretary of War shall approve the plan and location of the said bridge, and notify the said company of the same in writing, the bridge shall not be built or commenced; and should any change be made in the plan of the bridge during the progress of the work thereon, such change shall be subject likewise to the approval of the Secretary of War. —notification of approval, etc.

SEC. 5. That said bridge shall be constructed to provide for the passage of railroad trains, and, at the option of the corporation by which it may be built, may be used for the passage of wagons and vehicles of all kinds, for the transit of animals, and for foot passengers for such reasonable rates of toll as may be approved from time to time by the Secretary of War: *Provided*, That all railroad companies desiring the use of the bridge authorized by this Act shall have and be entitled to equal rights and privileges relative to the passage of trains or cars over the same and over the approaches thereto upon the payment of a reasonable compensation for such use; and in case the owner or owners of such bridge and the several companies, or any one of them, desiring such use shall fail to agree upon the sum or sums to be paid, and upon the rules and conditions to which each shall conform in using said bridge, all matters at issue between them shall be decided by the Secretary of War upon a hearing of the allegations and proofs of the parties; and equal privileges in the use of said bridge shall be granted to all telegraph and telephone companies. Transit, toll, etc. *Proviso.* Right of railroads to use, etc. Telegraph, etc., companies.

SEC. 6. That any bridge constructed under this Act shall be a lawful structure and shall be known as a post road, over which no higher charge shall be made for the transportation of mails, troops, and munitions of war, or other property of the Government of the United States, or for passengers or freight passing over the same, than the rate per mile charged for their transportation over the railways or public highways leading to said bridge. The United States shall also have the right of way over said bridge for postal telegraph purposes. To be lawful structure and post route.

SEC. 7. That said bridge herein authorized to be constructed shall be so kept and managed at all times as to afford proper means and ways for the passage of vessels, barges, or rafts, both by day and by night; and there shall be displayed on said bridge by the owners thereof, from sunset to sunrise, such lights or other signals as the Light-House Board may prescribe; and such changes shall be made from time to time in the structure of said bridge Aids to navigation. Lights. Changes.

as the Secretary of War may direct, at the expense of the said company, in order the more effectually to preserve the free navigation of said river.

Commencement and completion.

SEC. 8. That this Act shall be null and void unless the construction of said bridge shall be commenced within one year and completed within three years from the passage of this Act.

Amendment.

SEC. 9. That Congress shall have power at any time to alter, amend, or repeal this Act.

Approved, March 2, 1900.

March 6, 1900.

CHAP. 34.—An Act Authorizing the construction of a bridge across the Mississippi River at Dubuque, Iowa.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

Dubuque and Wisconsin Bridge Company may bridge Mississippi River at Dubuque.

That the Dubuque and Wisconsin Bridge Company, a corporation duly incorporated under the laws of the State of Iowa, its successors and assigns, be, and is hereby, authorized to construct and maintain, at a point suitable to the interests of navigation, a bridge for the passage of vehicles of all kinds, animals, and foot passengers across the Mississippi River from a point at or near Eagle Point, in the city of Dubuque, in the State of Iowa, to the opposite shore of said river in the county of Grant, in the State of Wisconsin; that said bridge shall not be built within two miles of any other bridge on said river following the course of the main channel; that the location and

Secretary of War to approve plans, etc.

plan or manner of constructing said bridge shall be subject to the approval of the Secretary of War, and until decided by him to be such as will not materially affect the interests of navigation the said bridge shall not be built; and there shall be submitted to the Secretary of War for his examination and approval a design and drawing of the proposed bridge and a map of the location, giving, for the space of a mile above and below the proposed location, the topography of the banks of the river, the shore line at high and low water, the direction and strength of the currents at all stages, and the soundings, accurately showing the bed of the stream, the location of any other bridge, and all other information required, and should any change be made in the plan of said bridge during the progress of construction such change shall be subject to the approval of the Secretary of War, and the said

Aids to navigation.

structure shall at all times be so kept and managed and be provided with such guard fences, sheer booms, and other structures as to offer reasonable and proper means for the passage of vessels and other floating craft through or under said structure; and for the safety of vessels

Lights, etc.

passing at night there shall be displayed on said bridge from the hours of sunset to sunrise such lights as may be prescribed by the Light-House Board; and the said structure shall be changed at the cost and the expense of the owners thereof, from time to time, as the Secretary of

War may direct, so as to preserve the free and convenient navigation of said river.

Spans.

SEC. 2. That said bridge between the Iowa shore and the lowlands or islands on the Wisconsin side of the river shall be constructed with unbroken and continuous spans, and the main span shall be over the main navigable channel of the river, and shall give a clear width of waterway not less than three hundred and fifty feet, and shall give clear headroom the full length of said span of not less in any case than fifty-five feet above extreme high-water mark, as understood at the point of location. The remaining spans shall each give a clear width of waterway of not less than two hundred feet, and a clear headroom of not less in any case than ten feet between extreme high water mark and the lower chords of the superstructure. Said bridge shall be constructed at right angles to, and its piers parallel with, the current of the river.

Toll.

SEC. 3. That said Dubuque and Wisconsin Bridge Company shall have the right to charge and collect a reasonable rate of toll for the passage across said bridge of vehicles, animals, and foot passengers, and travelers, subject to approval by the Secretary of War.

Commencement and completion.

SEC. 4. That this Act shall be null and void if actual construction of the bridge herein authorized be not commenced within eighteen months, and completed within three years from the date of the passage hereof.

To be lawful structure and post route.

SEC. 5. That the bridge built under this Act and subject to its limitations shall be a lawful structure, and shall be known and recognized as a post route, and it shall enjoy the rights and privileges of other post-roads of the United States; and equal privileges in the use of said bridge shall be granted to all telegraph and telephone companies; and the United States shall have the right of way across said bridge and its approaches for postal-telegraph purposes.

Telegraph, etc., companies.

Amendment.

SEC. 6. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

Approved, March 6, 1900.

March 9, 1900.

CHAP. 36.—An Act Extending the time for the completion of the bridge across the East River, between the city of New York and Long Island, now in course of construction, as authorized by the Act of Congress approved March third, eighteen hundred and eighty-seven.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the time for the completion of the bridge of the New York and Long Island Bridge Company across the East River between the city of New York and Long Island, authorized by the Act of Congress entitled "An Act authorizing the construction of a bridge across the East River between the city of New York and Long Island," approved March third, eighteen hundred and eighty-seven, and the various Acts amendatory thereof or sup-

Time extended for bridging East River at New York City.

Vol. 24, p. 468.

plementary thereto, is hereby extended to and including the first day of January in the year nineteen hundred and five.

Approved, March 9, 1900.

March 9, 1900.

CHAP. 37.—An Act To provide for the erection of a bridge across Rainy River, in the State of Minnesota, between Rainy Lake and the mouth of Rainy River.

Minnesota and Ontario Bridge Company may bridge Rainy River, Minn.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Minnesota and Ontario Bridge Company, a corporation duly incorporated under the laws of the State of Minnesota, be, and the same is hereby, authorized and empowered to erect, construct, and maintain a bridge over Rainy River at or near a point on Rainy River that is known as Cathcarts Point, in the State of Minnesota, just below the confluence of the Baudette River with Rainy River: *Provided,* That the plan, location, and elevation of the bridge, so far as the interests of navigation are concerned, shall be recommended by a board of three officers of the Corps of Engineers, which shall be appointed by the Secretary of War to consider the same; and it shall be the duty of the said board to give a public hearing in the city of Minneapolis to all parties interested whenever the designs and drawings of the said bridge and maps of location shall have been submitted to the Secretary of War, as hereinafter provided. The said board shall give reasonable notice, by publication in the newspapers, of the time and place of such hearing, and report its recommendations to the Secretary of War as soon thereafter as may be expedient.

Proviso. Board to consider plans, etc.

—hearing.

—notice of.

—report.

To be lawful structure and post route.

SEC. 2. That any bridge built under this Act and subject to its limitations shall be a lawful structure, and shall be recognized and known as a post route, upon which also no higher charge shall be made for the transportation over the same of the mails, the troops, and munitions of war of the United States than the rate per mile paid for the transportation over the railroads or public highways leading to the said bridge, and it shall enjoy the rights and privileges of other post roads in the United States.

Draw.

Height, etc.

Not to obstruct navigation.

Lights.

SEC. 3. That the said bridge shall have a draw or draws over the main channel of the river, leaving a clear waterway of not less than one hundred and sixty feet on one side of the pivot pier. The height of the superstructure above water shall be fixed and determined by the Secretary of War. The bridge shall be at right angles to, and its piers parallel with, the current of the river. No bridge shall be erected or maintained under the authority of this Act which shall at any time unreasonably obstruct the navigation of the said river. During the construction of the bridge, the navigable channel of the river shall not be obstructed to a greater extent than in the opinion of the Secretary of War is absolutely necessary, and such lights

and buoys shall be kept on all cofferdams, piles, and other obstructions as may be required during navigation. In case of any litigation arising from obstruction or alleged obstruction to the free navigation of said river, caused or alleged to be caused by said bridge, the circuit court of the United States of the circuit within which said bridge may be located shall have jurisdiction thereof: *Provided*, That nothing in this Act shall be so construed as to repeal or modify any of the provisions of law now existing in reference to the protection of the navigation of rivers, or to exempt this bridge from the operation of the same.

Litigation.

Proviso. Existing law unchanged.

SEC. 4. That all railroad companies in this country or Canada desiring the use of said bridge shall be entitled to equal rights and privileges relative to the passage of railway trains or cars over the same and over the approaches thereto, and the rates charged for the use of said bridge shall be the same for all companies alike, and without discrimination of any kind in favor of or against either over the whole length of the bridge and approaches: *Provided*, That if any question of difference arises at any time between said bridge company and any railroad company using said bridge or desiring its use in respect of the rate of compensation to be paid for such use or in respect of any other matter pertaining to such use and the parties can not agree in regard to the same, such question shall be determined by the Secretary of War on application to him by either party to such matter of difference and due notice to all other parties interested. The parties shall be heard by the Secretary, and they shall have the opportunity of producing testimony. The determination of any such question by the Secretary of War shall be conclusive on the parties: *Provided*, That his decision may from time to time, as becomes necessary, be revised and modified by him.

Railroads, rights of, as to use of bridge.

Provisos. —Secretary of War to decide differences of, with bridge company.

—revision of decision.

SEC. 5. That any bridge authorized to be constructed under this Act shall be built and located under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe, and to secure that object the said company or corporation shall submit to the Secretary of War, for his examination and approval, a design and drawings of the bridge and a map of the location, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and the said company or corporation shall cause to be displayed on said bridge, from the hours of sunset to sunrise, or at other times, such lights or other signals as may be prescribed by the Light-House Board.

Secretary of War to approve plans, etc.

Lights.

SEC. 6. That the draw or draws shall be opened promptly upon reasonable signal for the passage of boats, vessels, or other water craft; and at the time of the erection of the piers, or whenever in the opinion of the Secretary of War the same may be necessary, the persons or corporations constructing, owning, or operating said bridge shall, at their own expense, construct proper sheer booms or other proper structures to safely guide boats, vessels, or other water craft through the said spans.

Opening of draw.

Aids to navigation.

Commencement and completion.

SEC. 7. That if the actual construction of the bridge hereby authorized shall not be commenced within two years from the date of approval of this Act, and be completed within four years after the same date, then this Act shall be void, and all rights hereby conferred shall cease and be determined; and that the construction shall not be commenced until the Government of the Dominion of Canada has authorized the construction and maintenance of that part of said bridge which shall occupy that portion of the said Rainy River which is under the jurisdiction of said Dominion government.

Construction of Canadian side of bridge.

Amendment.

SEC. 8. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

Approved, March 9, 1900.

March 9, 1900.

CHAP. 38.—An Act To extend the time for the completion of a bridge across the Missouri River.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That section six of the Act approved March third, eighteen hundred and ninety-nine, authorizing the Dakota Southern Railroad Company to construct a combined railroad, wagon, and foot-passenger bridge across the Missouri River, at the city of Yankton, South Dakota, be, and is hereby, amended by extending the time for commencing the construction of said bridge to March third, nineteen hundred and one, and by extending the time for completing said bridge to March third, nineteen hundred and four.

Time extended for bridging Missouri River at Yankton.
Vol. 30, p. 1361.

Approved, March 9, 1900.

March 23, 1900.

CHAP. 88.—An Act Declaring Cuivre River to be not a navigable stream.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That Cuivre River, in the counties of Lincoln and Saint Charles, in the State of Missouri, being the dividing line, is hereby declared not to be a navigable stream, and shall be so treated by the Secretary of War and all other authorities.

Cuivre River, Missouri, declared not navigable.

Approved, March 23, 1900.

March 29, 1900.

CHAP. 116.—An Act To authorize the Cambridge Bridge Commission to construct a drawless bridge across the Charles River, in the State of Massachusetts.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Cambridge Bridge Commission be, and hereby is, authorized to construct a drawless bridge across the Charles River, in the State of Massachusetts, between the cities of Boston and Cambridge, as provided for by

Cambridge Bridge Commission may bridge Charles River, Mass.

chapter four hundred and sixty-seven of the acts of eighteen hundred and ninety-eight, and chapter one hundred and eighty of the acts of eighteen hundred and ninety-nine, of the legislature of the State of Massachusetts; said bridge to be at least twenty-six feet above mean high water over the main ship channel, and the piers and other obstructions to the flow of the tide to be constructed in such form and in such places as the Secretary of War shall approve: *Provided*, That the State of Massachusetts, within a reasonable time after the completion of said bridge, by legislative enactment, shall provide for adequate compensation to the owner or owners of wharf property now used as such on said river above said bridge, for damages, if any, sustained by said property by reason of interference with access by water to said property now and hitherto enjoyed, because of the construction of said bridge without a draw.

Proviso. Compensation to owners of wharf property, etc.

Approved, March 29, 1900.

CHAP. 187.—An Act Declaring certain trestles of the Washington County Railroad Company to be lawful structures.

April 12, 1900.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the trestle on the Eastport Branch of the Washington County Railroad, being the property of the Washington County Railroad Company, and running from the extreme point of land south of Pleasant Point, in the town of Perry, county of Washington and State of Maine, to the extreme northern end of Carlows Island, in the town of Eastport, in said county and State; and a certain other trestle, also the property of said railroad company, in the East Machias River, in said county of Washington and State of Maine, at the extreme end of said river, near the village of East Machias, in said county and State, be, and both of said trestles hereby are, declared to be lawful structures: *Provided*, That such modifications are made in their present position, condition, and elevation as the Secretary of War may order in the interests of navigation.

Washington County Railroad. Certain trestles belonging to, declared lawful structures.

Proviso. —changes of position, etc.

Approved, April 12, 1900.

CHAP. 189.—An Act Permitting the building of a dam between Coon Rapids and the north limits of the city of Minneapolis, Minnesota, across the Mississippi River.

April 12, 1900.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the consent of Congress is hereby granted to the Twin City Rapid Transit Company, its successors or assigns, to construct across the Mississippi River, at any point between Coon Rapids and the north line of the limits of the city of Minneapolis, a dam, canal, and works neces-

Twin City Rapid Transit Company may dam Mississippi River at Coon Rapids, etc

sarily incident thereto, for water-power purposes. The said dam shall be so constructed that there can, at any time, be constructed in connection therewith a suitable lock for navigation purposes: *Provided, also*, That the Government of the United States may at any time take possession of said dam and appurtenant works and control the same for purposes of navigation by paying the said company the value not exceeding the actual cost of the same, but shall not do so to the destruction of the water power created by said dam to any greater extent than may be necessary to provide proper facilities for navigation: *Provided further*, That the works shall be constructed so as to provide for the free passage of saw logs. The said Twin City Rapid Transit Company shall make such change and modification in the works as the Secretary of War may from time to time deem necessary in the interests of navigation, at its own cost and expense: *Provided further*, That in case any litigation arises from the obstruction of the channel by the dam, canal, or appurtenant works, the case may be tried in the proper Federal court of the United States in which the works are situated.

Provisos. Government control. Passage of saw logs. Changes. Litigation.

SEC. 2. That the right to amend, alter, or repeal this Act is hereby expressly reserved: *And provided further*, That suitable fishways, to be approved by the United States Fish Commissioner, shall be constructed and maintained at said dam by the Twin City Rapid Transit Company, its successors or assigns.

Amendment. *Proviso.* Fishways.

SEC. 3. That this Act shall become null and void unless the dam herein authorized be commenced on or before the first day of July, nineteen hundred and one, and be completed within three years thereafter.

Commencement and completion.

Approved, April 12, 1900.

April 12, 1900.

CHAP. 190.—An Act To authorize the Shreveport and Red River Valley Railway Company to build and maintain a railway bridge across Red River, at or near the town of Alexandria, in the parish of Rapides, State of Louisiana.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Shreveport and Red River Valley Railway Company, a corporation duly incorporated and existing under and by virtue of the laws of the State of Louisiana, be, and is hereby, authorized to construct and maintain, by itself or through its assignees, a railway bridge across Red River at a point suitable to the interest of navigation, at or near the town of Alexandria, in the parish of Rapides, State of Louisiana. Said bridge shall be constructed to provide for passage of railway trains, and for transmission of the mails at such legal rates of toll as may be fixed by said railway company, or its transferees, and approved by the Secretary of War.

Shreveport and Red River Valley Railway may bridge Red River at Alexandria, La. Transit, tolls, etc.

SEC. 2. That said bridge, built under this Act and subject to its limitations, shall be a lawful structure, and shall be recognized and known as a post route, upon which

To be lawful structure and post route.

also no higher charge shall be made for the transmission over the same of the mails, the troops, and munitions of war of the United States than the rate per mile paid for the transportation over the railroad or public highways leading to the said bridge, and shall enjoy the rights and privileges of other post-roads in the United States; and equal privileges in the use of said bridge shall be granted to all telegraph and telephone companies; and the United States shall have the right of way across said bridge and its approaches for postal telegraph purposes: *Provided*, That the bridge herein authorized to be constructed shall be so kept and managed by the company owning or operating it as to afford proper ways and means for the passage through or under it of vessels, barges, or rafts at all times, both by day and by night; and if said bridge be constructed as a drawbridge, the draw shall be opened promptly upon reasonable signal for the passage of boats; and upon whatever kind of bridge is built there shall be displayed on said bridge from sunset to sunrise, at the expense of said company, such lights and signals as the Light-House Board shall prescribe.

Telegraph, etc., companies.

Proviso.
Aids to navigation.

Draw.

Lights.

SEC. 3. That if said bridge, erected and maintained under the authority of this Act, shall at any time substantially or materially obstruct the free navigation of said river, or shall, in the opinion of the Secretary of War, obstruct such navigation, he is hereby authorized to cause such change or alteration of said bridge to be made as will effectually obviate such obstruction; and such alteration shall be made and all such obstructions be removed at the expense of the owners or operators of said bridge; and in case of any litigation arising from the obstruction or alleged obstruction to the free navigation of said river, the case may be brought in the district court of the United States for the western district of Louisiana: *Provided*, That nothing in this Act shall be so construed as to repeal or modify any of the provisions of law now existing in reference to the protection of the navigation of rivers, or to exempt said bridge from the operation of same.

Alterations.

Litigation.

Proviso.
Existing law unchanged, etc.

SEC. 4. That all railroad companies desiring to use the said bridge shall have and be entitled to equal rights and privileges relative to the passage of railway trains over the same and the approaches thereto upon the payment of a reasonable compensation for such use, which compensation may be different in case of different railways. In case of disagreement as to compensation for the use of said bridge, the difference shall be determined by the Secretary of War upon hearing the allegations and proof of the parties in interest.

Railroad rights to use.

SEC. 5. That the bridge authorized to be constructed under this Act shall be built and located under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe; and to secure that object the said company or corporation shall submit to the Secretary of War, for his examination and approval, a design and drawing of said bridge, and a map of the location, prepared with reference to known datum

Secretary of War to approve plans, etc.

plane upon prescribed scales furnished by the engineer officer having supervision of said river, and giving, for the space of two miles above and two miles below the proposed location of the bridge, the topography of the banks of the river, with shore lines at high and low water, the direction and strength of the currents at all stages, and the soundings accurately showing the bed of the stream, the location of any other bridge or bridges, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject. And until said plans and location of the bridge are approved by the Secretary of War the bridge shall not be built; and should any change be made in the plan of the said bridge during the process of construction, such change shall be subject to the approval of the Secretary of War, and said structure shall be changed at the cost and expense of the owners thereof, from time to time, as the Secretary of War may direct, so as to preserve the free and convenient navigation of said river.

Commencement and completion.

SEC. 6. That this Act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year and completed within three years from the date hereof.

Amendment.

SEC. 7. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

Approved, April 12, 1900.

April 17, 1900.

CHAP. 192.—An Act Making appropriations for the legislative, executive, and judicial expenses of the Government for the fiscal year ending June thirtieth, nineteen hundred and one, and for other purposes.

Legislative, executive, and judicial expenses appropriations.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums be, and the same are hereby, appropriated, out of any money in the Treasury not otherwise appropriated, in full compensation for the service of the fiscal year ending June thirtieth, nineteen hundred and one, for the objects hereinafter expressed, namely:

* * * * *

War Department.

WAR DEPARTMENT.

* * * * *

Office Chief of Engineers.

OFFICE OF THE CHIEF OF ENGINEERS: For chief clerk, two thousand dollars; five clerks of class four; four clerks of class three; four clerks of class two; four clerks of class one; one clerk, one thousand dollars; one assistant messenger, and two laborers; in all, thirty thousand eight hundred and forty dollars.

Skilled draftsmen.

And the services of skilled draftsmen, civil engineers, and such other services as the Secretary of War may deem necessary may be employed in the office of the Chief of Engineers to carry into effect the various appropriations for rivers and harbors, fortifications, and surveys to be

paid from such appropriations: *Provided*, That the expenditures on this account for the fiscal year ending June thirtieth, nineteen hundred and one, shall not exceed seventy-two thousand dollars; and that the Secretary of War shall each year, in the annual estimates, report to Congress the number of persons so employed and the amount paid to each.

Proviso. —limit of expenditure.

* * * * *

PUBLIC BUILDINGS AND GROUNDS.

Public buildings and grounds.

OFFICE OF PUBLIC BUILDINGS AND GROUNDS: For one assistant engineer, one thousand eight hundred dollars; one office clerk, one thousand eight hundred dollars; one clerk, one thousand six hundred dollars; one messenger; landscape gardener, two thousand dollars; one surveyor and draftsman, one thousand five hundred dollars; in all, nine thousand five hundred and forty dollars.

Clerks, etc

For overseers, draftsmen, foremen, gardeners, mechanics, and laborers employed in the public grounds, thirty-three thousand dollars.

Overseers, etc.

For one sergeant of watchmen, nine hundred dollars.

For day watchmen as follows: One in Franklin Park; one in Lafayette Park; two in Smithsonian Grounds; one in Judiciary Park; one in Lincoln Park and adjacent reservations; one at Iowa Circle; one at Thomas Circle and neighboring reservations; one at Washington Circle and neighboring reservations; one at Dupont Circle and neighboring reservations; one at McPherson and Farragut parks; one at Stanton Park and neighboring reservations; two at Henry and Seaton parks; one at Mount Vernon Park and adjacent reservations; one for the greenhouses and nursery; one at grounds south of Executive Mansion; one at Garfield Park; eighteen in all, at six hundred and sixty dollars each, eleven thousand eight hundred and eighty dollars.

Watchmen.

For night watchmen as follows: Two in Smithsonian Grounds; one in Judiciary Park; two in Henry and Seaton parks; one in grounds south of Executive Mansion; one in Monument Park; and two in Garfield Park; nine in all, at seven hundred and twenty dollars each, six thousand four hundred and eighty dollars.

For watchman for the care of the monument and dock at Wakefield, Virginia, the birthplace of Washington, three hundred dollars.

Wakefield, Va.

For contingent and incidental expenses, including purchase of professional and scientific books and periodicals, books of reference, blank books, photographs, and maps, seven hundred dollars.

Contingent expenses.

Of the foregoing amounts appropriated under Public Buildings and Grounds, the sum of twenty-seven thousand one hundred and thirty dollars shall be paid out of the revenues of the District of Columbia.

Amount payable from revenues of District of Columbia.

* * * * *

Approved, April 17, 1900.

April 21, 1900. **CHAP. 250.**—An Act To legalize and maintain the iron bridge across Pearl River at Rockport, Mississippi.

Preamble.

Whereas the boards of supervisors of Copiah and Simpson counties, Mississippi, did, in eighteen hundred and ninety-eight, jointly contract for an iron bridge to be built across Pearl River, at Rockport, Mississippi, believing that said stream at this point was practically nonnavigable; that afterwards an injunction was sued out by the Government, restraining contractors, which, being heard before Judge H. C. Niles, of the district Federal court at Jackson, Mississippi, he decided that the part of Pearl River from Rockport to Jackson was a nonnavigable stream and dissolved the injunction; that an iron bridge was built in accordance with said contract and opened for travel in August, eighteen hundred and ninety-nine, without a draw; that in January, nineteen hundred, an appeal was taken by the Government to the United States circuit court and is now pending; and

Whereas said boards of supervisors are desirous of complying with their obligation with the bridge company and giving the citizens of said counties the benefit of said bridge, which is of great public utility: Therefore,

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

Bridge across Pearl River at Rockport, Miss., legalized.

That the bridge aforesaid be, and the same is hereby, legalized and maintained as constructed by said counties for the use of the general public.

Amendment.

SEC. 2. That Congress reserves the right to alter, amend, or repeal this Act at pleasure.

Received by the President, April 10, 1900.

[NOTE BY THE DEPARTMENT OF STATE.—The foregoing act having been presented to the President of the United States for his approval, and not having been returned by him to the house of Congress in which it originated within the time prescribed by the Constitution of the United States, has become a law without his approval.]

April 30, 1900. **CHAP. 340.**—An Act To authorize the construction of a bridge across Tallahatchie River, in Tallahatchie County, Mississippi.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

Tallahatchie county, Miss., may bridge Tallahatchie River, etc.

That the board of supervisors of Tallahatchie County, in the State of Mississippi, be, and is hereby, authorized to construct and maintain a bridge and approaches thereto across the Tallahatchie River at or within one mile above or below Swan Lake, in the State of Mississippi.

Transit, toll, etc.

Said bridge shall be constructed to provide for the passage of wagons and vehicles of all kinds, animals, foot passengers, and for all road travel, for such reasonable rates of toll and under such reasonable rules and

regulations as may be prescribed by said board of supervisors and approved by the Secretary of War.

SEC. 2. That any bridge built under this Act and subject to its limitations shall be a lawful structure, and shall be recognized and known as a post route, upon which no charge shall be made for the transmission over the same of the mails, the troops, and munitions of war of the United States; and equal privileges in the use of said bridge shall be granted to all telegraph and telephone companies; and the United States shall have the right of way across said bridge and its approaches for postal-telegraph purposes.

To be lawful structure and post route.

Telegraph, etc., companies.

SEC. 3. That the said bridge shall be constructed as a wagon bridge, and shall contain a drawspan giving a clear opening of a width to be determined by the Secretary of War, which drawspan shall be maintained over the main channel of the river at an accessible and navigable point; and said bridge other than the drawspan shall be at right angles to the current of the river at high water: *Provided*, That the said draw shall be opened promptly, upon reasonable signal, for the passage of boats and rafts; and said board of supervisors shall maintain, at its own expense, from sunset to sunrise, such lights or other signals on said bridge as the Light-House Board shall prescribe. No bridge shall be erected or maintained under the authority of this Act which shall at any time unreasonably obstruct the free navigation of said river; and if any bridge erected under such authority shall, in the opinion of the Secretary of War, unreasonably obstruct navigation, he is hereby authorized to cause the entire removal thereof or such changes or alterations of said bridge to be made as will obviate such obstruction; and all such alterations shall be made and all such obstructions shall be removed at the expense of the owner or owners of said bridge; and in case of any litigation arising from any obstruction or alleged obstruction to the free navigation of said river, caused or alleged to be caused by said bridge, the case may be brought in the district court of the United States of the State of Mississippi, in whose jurisdiction any portion of said obstruction or bridge may be located: *Provided further*, That nothing in this Act shall be so construed as to repeal or modify any of the provisions of the law now existing in reference to the protection of the navigation of rivers, or to exempt this bridge from the operation of same.

Draw, etc.

Provisos. Opening of.

Lights.

Obstructions to navigation.

Changes.

Litigation.

Existing law protecting navigation of rivers unchanged.

SEC. 4. That any bridge authorized to be constructed under this Act shall be built and located under and subject to such regulations for the security of navigation of the said river as the Secretary of War shall prescribe; and to secure that object the said board of supervisors shall submit to the Secretary of War, for his examination and approval, a design and drawing of the bridge, and a map of the location, giving, for the space of one-half mile above and one-half mile below the proposed location, the high and low water lines upon the banks of the river, the

Secretary of War to approve plans, etc.

direction and strength of the currents at low and at high water, with the soundings accurately showing the bed of the stream, and the location of any other bridge or bridges, such maps to be sufficiently in detail to enable the Secretary of War to judge of the proper location of said bridge, and shall furnish such other information as shall be required for a full and satisfactory understanding of the subject; and until the said plan and location of the bridge are approved by the Secretary of War the bridge shall not be commenced or built; and should any change be made in the plans of said bridge during the progress of its construction, or after completion, such changes shall be subject to the approval of the Secretary of War.

Commencement and completion.

SEC. 5. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year and completed within three years from the date thereof: *Provided*, That Congress reserves the right to alter, amend, or repeal this Act whenever the public interests so require.

Proviso. Amendment.

Approved, April 30, 1900.

April 30, 1900.

CHAP. 341.—An Act To authorize the Ohio Valley Electric Railway Company to construct a bridge over the Big Sandy River from Kenova, West Virginia, to Catlettsburg, Kentucky.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That it shall be lawful for the Ohio Valley Electric Railway Company, a corporation organized under the laws of the State of West Virginia, to construct and maintain a bridge, and approaches thereto, over the Big Sandy River from a point in the town of Kenova, West Virginia, to a point in the town of Catlettsburg, Kentucky.

Ohio Valley Electric Railway may bridge Big Sandy River.

Transit, toll, etc.

SEC. 2. That said bridge may be constructed to provide for the passage of railroad cars, wagons, and vehicles of all kinds, for the transit of animals, foot passengers, and all kinds of commerce, travel, or communication; and said corporation may charge and receive reasonable tolls therefor, subject to the approval of the Secretary of War, and to such changes as he may think proper from time to time.

Piers, spans, etc.

SEC. 3. That said bridge shall have its piers parallel to the current at high water due to a rise in the Big Sandy River; that all of its spans shall be through spans; that it shall have a clear channel way of at least one hundred and eighty-three feet, measured at the low-water level and perpendicular to the current at that stage; that said clear channel way shall be located over the main channel of the river; that none of the spans lying between the shore lines of the river at a bank-full stage shall have less than one hundred and eighty-three feet clear opening between piers; and that all such spans shall give a clear headroom of not less than sixty-nine and five-tenths feet, measured from low water to the lowest point of the superstructure, or of anything thereto attached.

Secretary of War to approve plans, etc.

SEC. 4. That said Ohio Valley Electric Railway Company shall submit in triplicate to the Secretary of War, for his examination and approval, a design and drawings of the bridge, piers, approaches, and accessory works, and a map of the location, giving, for the space of at least one mile above and one mile below the proposed site, the topography of the banks of the river and the shore lines at high and low water, the direction and strength of the currents at low water and at high water, the location of all bridges, locks and dams, coal tipples, cribs, and all other structures projecting into the river at bank-full stage, in the vicinity, and such other information as the Secretary of War may require for a full and satisfactory understanding of the subject; and until such plan and location of the bridge and accessory works are approved by the Secretary of War the bridge shall not be commenced or built; and should any change be made in the plan of said bridge during the progress of construction, or after completion, such change shall be subject to the approval of the Secretary of War.

Aids to navigation.

SEC. 5. That said bridge herein authorized to be constructed shall be so kept and managed at all times as to afford proper means and ways for the passage or vessels, barges, or rafts, both by day and by night; and there shall be displayed on said bridge by the owners thereof, from sunset to sunrise, such lights or other signals as the Light-House Board may prescribe; and such indications of the stage of water and the headroom under the bridge as the Secretary of War may direct shall be displayed by the owners thereof; and such changes shall be made from time to time in the structure of said bridge as the Secretary of War may direct, at the expense of the said company, in order the more effectually to preserve the free navigation of said river.

Lights.

Changes.

To be lawful structure and post route.

SEC. 6. That said bridge shall be a lawful structure and shall be recognized and known as a post route, upon which also no higher charge shall be made for the transportation over the same of the mails, the troops, and the munitions of war of the United States than the rate per mile paid for the transportation of said mails, troops, and munitions over the railroads and public highways leading to said bridge; and the United States shall have the right of way for postal-telegraph and telephone purposes over said bridge.

Right of railways to use.

SEC. 7. That all railway companies desiring the use of said bridge shall have and be entitled to equal rights and privileges relative to the passage of railway trains or cars over the same and over the approaches thereto, upon payment of a reasonable compensation for such use; and in case the parties interested shall fail to agree upon the sum or sums to be paid, and upon the rules and conditions to which each shall conform in using said bridge, all matters at issue between them shall, upon the application of either party, be determined by the Secretary of War upon a hearing of the allegations and proofs of the parties.

Navigable channel during construction, etc.

SEC. 8. That during the original construction of said bridge, or in carrying out any authorized changes or repairs of said bridge, a navigable channel sufficient to accommodate the commerce of the river shall be preserved at all times at the site of said bridge, and the waterway of the river shall not be obstructed to a greater extent than is absolutely necessary, and such lights and buoys shall be kept on all cofferdams, piles, and other structures as may be necessary for the security of navigation; and that any temporary obstruction or closing of any channel in customary use shall not be commenced until after due notice to navigation; and all cofferdams, piles, and other structures used in the construction or repair of said bridge shall be removed within a reasonable time after the completion or repair of said bridge.

Commencement and completion.

SEC. 9. That this Act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year and completed within three years from the date hereof.

Amendment.

SEC. 10. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

Approved, April 30, 1900.

May 4, 1900.

CHAP. 345.—An Act Authorizing the Cape Nome Transportation, Bridge, and Development Company, a corporation organized and existing under the laws of the State of Washington and authorized to do business in the Territory of Alaska, to construct a traffic bridge across the Snake River, at Nome City, in the Territory of Alaska.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

Cape Nome Transportation, Bridge, etc., Company may bridge Snake River, Alaska.

That the Cape Nome Transportation, Bridge, and Development Company, a corporation organized and existing under the laws of the State of Washington and authorized to do business in the Territory of Alaska, is hereby authorized and empowered to construct, operate, and maintain a general traffic bridge across the Snake River, to be located at such point within or near the corporate limits of the city of Nome, in said Territory of Alaska, as shall be approved by the Secretary of War: *Provided*, That said bridge shall be constructed as a drawbridge, and the draw shall be opened promptly, upon reasonable signal, for the passage of boats; and, whatever kind of bridge is constructed, the owners thereof shall maintain thereon, at their own expense, from sunset to sunrise, such lights or other signals as the Light-House Board shall prescribe; that such bridge shall be constructed so as to provide for the passage of vehicles and pedestrians, upon the payment of a reasonable compensation for such use.

Proviso.
Draw.
Lights.
Transit.

To be lawful structure and post route.

SEC. 2. That any bridge built under the provisions of this Act shall be a lawful structure, and shall be recognized and known as a post route, upon which no higher charge shall be made for the transmission over the same of the mails, troops, and munitions of war of the United

States passing over said bridge than the rate per mile paid for the transportation over the public highways leading to said bridge; and equal privileges in the use of said bridge shall be granted to all telegraph and telephone companies, and the United States shall have the right of way across said bridge and approaches for postal-telegraph purposes; and said bridge shall be so constructed and operated as not to interfere with the navigation of said river. Telegraph, etc., companies.

SEC. 3. That the said corporation shall have the right to charge and collect a reasonable rate of toll, to be approved by the Secretary of War, not exceeding ten cents for pedestrians, twenty-five cents for animals, and fifty cents for vehicles. Toll.

SEC. 4. That the bridge authorized to be constructed under this Act shall be located and built under and subject to regulations for the security of the navigation of said river as the Secretary of War shall prescribe; and to secure that object the said corporation shall submit to the Secretary of War, for his examination and approval, a design and drawings of the proposed bridge and a map of the location, giving, for the space of one-half mile above and one-half mile below the proposed location, the topography of the banks of the river, the shore lines at high and low water, the direction and strength of the currents, and the soundings, accurately showing the bed of the stream, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until the said plan and location of the bridge are approved by the Secretary of War no work upon the bridge shall be commenced; and should any change be made in the plan of said bridge during the progress of construction such change shall be subject to the approval of the Secretary of War; and any changes in said bridge which the Secretary of War may at any time deem necessary and order in the interests of navigation shall be made by the owners thereof at their own expense. Secretary of War to approve plans.

SEC. 5. That this Act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year and completed within three years from the date of approval hereof. Commencement and completion.

SEC. 6. That Congress hereby expressly reserves the right to alter, amend, or repeal this Act. Amendment.

Approved May 4, 1900.

CHAP. 346.—An Act To amend an Act entitled "An Act permitting the building of a dam across Rainy Lake River." May 4, 1900.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That section three of an Act entitled "An Act permitting the building of a dam across Rainy Lake River," approved May fourth, eighteen hundred and ninety-eight, and granting to the Koochiching Company, its successors and Time extended to the Koochiching Company to dam Rainy Lake River, Minn.

Vol. 30, p. 398. assigns, the consent of Congress to construct a dam across the Rainy Lake River, be, and the same is hereby, amended so as to read as follows:

"That this Act shall be null and void unless the dam herein authorized shall be commenced within three years and completed within five years after the fourth day of May, eighteen hundred and ninety-eight."

Approved May 4, 1900.

May 4, 1900.

CHAP. 347.—An Act To authorize the New Orleans and Northwestern Railway Company, its successors and assigns, to build and maintain a bridge across Bayou Bartholomew in the State of Louisiana.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

New Orleans and Northwestern Railway may bridge Bayou Bartholomew, La.

That the New Orleans and Northwestern Railway Company, a corporation created, organized, and existing under the laws of the States of Louisiana and Mississippi be, and is hereby, authorized to construct and maintain a railway bridge and approaches thereto, over Bayou Bartholomew, in the State of Louisiana, at a point suitable, in the judgment of the Secretary of War, to the interests of navigation, near the north line of section twenty-five, township twenty-two north, range five east; said bridge shall be constructed for the passage of railway trains, and, at the option of the corporation by which it is built, may be used for the passage of wagons and vehicles of all kinds, for the transit of animals, and for foot passengers, for reasonable rates of toll, to be fixed by the said company and approved by the Secretary of War.

Transit.

Toll.

To be lawful structure and post route.

SEC. 2. That the said bridge, to be constructed under this Act, and subject to its limitations, shall be a lawful structure, and shall be recognized and known as a post road, and shall enjoy the rights and privileges of other post roads in the United States; that no higher charges shall be made for the transmission over the same of the mail, troops, and munitions of war of the United States or for through railway passengers or freight passing over said bridge than the rate per mile for their transmission over the roads leading to said bridge; and equal privileges in the use of said bridge shall be granted to all telegraph companies, and the United States shall have the right of way across said bridge for postal telegraph services; that the said bridge shall be constructed either as a drawbridge, or otherwise, so that a free and unobstructed passage may be secured to all water crafts navigating said river at the point aforesaid: *Provided*, That if the said bridge authorized to be constructed under this Act shall be constructed as a drawbridge, the draws shall be opened promptly upon reasonable signals for the passage of boats or vessels, and whatever kind of bridge is constructed the said corporation shall maintain thereon at its own expense, from sunset to sunrise, such lights or other signals as the Light-House Board shall prescribe.

Telegraph companies.

Draw.

Proviso.
—opening of.

Lights.

SEC. 3. That the bridge authorized to be constructed under this Act shall be built and located under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe, and to secure that object the said company or corporation shall submit to the Secretary of War, for his examination and approval, designs and drawings of the said bridge, and a map of the location of same, giving the topography of the banks of the river or bayou, the shore line at high and low water, and the direction and strength of the current at different stages, the location of any other bridge or bridges within one mile thereof, and such further information as may be required for a satisfactory understanding of the subject; and said bridge shall not be constructed until the plan and location is approved by the Secretary of War. All litigation which shall be had in regard to the said bridge shall be in the circuit court of the United States in whose jurisdiction the said bridge is located. Secretary of War to approve plans. Litigation.

SEC. 4. That the right to alter, amend, or repeal this Act is hereby reserved; and any alterations or changes that may be required by the Secretary of War in the bridge constructed under this Act shall be made by the corporation owning or controlling the same at its own expense. Furthermore, if the construction of the said bridge shall not be commenced within one year and completed within three years after the passage of this Act all the privileges conferred hereby, and this Act, shall become null and void. Amendment. Changes. Commencement and completion.

Approved, May 4, 1900.

CHAP. 348.—An Act To authorize the Atlantic and Gulf Short Line Railroad Company to build, construct, and maintain railway bridges across the Ocmulgee and Oconee rivers within the boundary lines of Irwin, Wilcox, Telfair, and Montgomery counties, in the State of Georgia. May 4, 1900.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Atlantic and Gulf Short Line Railroad Company, a corporation duly incorporated and existing under and by virtue of the laws of the State of Georgia, be, and it is hereby, authorized to construct, build, and maintain across the Ocmulgee River a railroad bridge for the passage of railroad engines and cars, at such point as may be selected by said company and approved by the Secretary of War, within Irwin, Wilcox, and Telfair counties, in the State of Georgia, the said Ocmulgee river being the dividing line between said counties of Irwin and Wilcox on the west and Telfair on the east side of said river. Atlantic and Gulf Short Line Railroad may bridge Ocmulgee and Oconee rivers, Ga.

SEC. 2. That the said Atlantic and Gulf Short Line Railroad Company is hereby authorized to build, construct, and maintain a railroad bridge for the passage of railroad engines and cars across the Oconee River, in the county of Montgomery, State of Georgia, at such point as Oconee River.

may be selected by said company and approved by the Secretary of War.

No obstruction to navigation. Draws. *Provisos.* To be lawful structures and post routes.

SEC. 3. That the bridges are to be so constructed as not to obstruct the navigation of said rivers, and to be provided each with a suitable draw: *Provided*, That the bridges constructed under this Act and according to its limitations shall be lawful structures and shall be known and recognized as post routes, and the same are hereby declared to be post routes, and the United States shall have the right of way for a postal telegraph across said bridges: *Provided further*, That all railroad companies desiring the use of said bridges and approaches shall have and be entitled to equal rights and privileges relative to the passage of trains over the same upon payment of a reasonable compensation for such use; and in case the owner or owners of said bridges and the several railroad companies, or any of them, desiring such use shall fail to agree upon the sum or sums to be paid, or upon rules and conditions to which each shall conform in using said bridges and approaches, all matters at issue between them shall be decided by the Secretary of War upon a hearing of the allegations and proofs of the parties.

Rights of railways to use.

Secretary of War to approve plans.

SEC. 4. That the bridges authorized to be constructed under this Act shall be located and built under and subject to such regulations for the security of the navigation of said rivers as the Secretary of War shall prescribe; and the said company or corporation shall submit to the Secretary of War, for his examination and approval, designs and drawings of the proposed bridges and maps of the locations, giving, for the space of one-fourth of a mile above and one-fourth of a mile below the proposed locations, the topography of the banks of the rivers, the shore lines at high and low water, the direction and strength of the currents, and the soundings, accurately showing the bed of the streams, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until the said plans and locations of the bridges are approved by the Secretary of War no work upon the said bridges shall be commenced; and should any change be made in the plans of said bridges during the progress of construction or after completion such change shall be subject to the approval of the Secretary of War.

Amendment. Alterations.

SEC. 5. That Congress reserves the right to alter, amend, or repeal this Act at any time; and that if at any time the navigation of said rivers shall in any manner be obstructed or impaired by the said bridges the Secretary of War shall have authority, and it shall be his duty, to require the said railroad company to alter and change the said bridges, at its own expense, in such manner as may be proper to secure free and complete navigation without impediment.

Draws.

SEC. 6. That the draws provided for the bridges herein authorized to be constructed shall be opened promptly, upon reasonable signal, for the passing of boats or other craft; and the said company or corporation shall maintain at its own expense from sunset to sunrise, such lights

Lights.

or other signals on said bridges as the Light-House Board may prescribe; and if actual construction of the bridges herein authorized shall not be commenced within one year from the passage of this Act, and be completed within three years from same date, the rights and privileges hereby granted shall cease and be determined.

Commencement and completion.

Approved, May 4, 1900.

May 9, 1900.

CHAP. 387.—An Act Authorizing the Secretary of War to make regulations governing the running of loose logs, steamboats, and rafts on certain rivers and streams.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the prohibition contained in section fifteen of the river and harbor Act, approved March third, eighteen hundred and ninety-nine, against floating loose timber and logs, or sack rafts, so called, of timber and logs in streams or channels actually navigated by steamboats, shall not apply to any navigable river or waterway of the United States or any part thereof whereon the floating of loose timber and logs and sack rafts of timber and logs is the principal method of navigation. But such method of navigation on such river or waterway or part thereof shall be subject to the rules and regulations prescribed by the Secretary of War as hereinafter provided.

Navigation. Exemption from prohibition against floating sack rafts in streams navigated by steamboats. Vol. 30, p. 1152.

SEC. 2. That the Secretary of War shall have power, and he is hereby authorized and directed, within the shortest practicable time after the passage hereof, to prescribe rules and regulations, which he may at any time modify, to govern and regulate the floating of loose timber and logs, and sack rafts (so called) of timber and logs and other methods of navigation on the streams and waterways, or any thereof, of the character, as to navigation, in section one hereof described. The said rules and regulations shall be so framed as to equitably adjust conflicting interests between the different methods or forms of navigation; and the said rules and regulations shall be published at least once in such newspaper or newspapers of general circulation as in the opinion of the Secretary of War shall be best adapted to give notice of said rules and regulations to persons affected thereby and locally interested therein. And all modifications of said rules and regulations shall be similarly published. And such rules and regulations when so prescribed and published as to any such stream or waterway shall have the force of law, and any violation thereof shall be a misdemeanor, and every person convicted of such violation shall be punished by a fine of not exceeding two thousand five hundred dollars nor less than five hundred dollars, or by imprisonment (in case of a natural person) for not less than thirty days nor more than one year, or by both such fine and imprisonment, in the discretion of the court: *Provided*, That the proper action to enforce the provisions of this section may be commenced before any commis-

Secretary of War to make regulations for floating logs, rafts, etc.

—publication.

force.

penalty.

Proviso. Procedure.

sioner, judge, or court of the United States, and such commissioner, judge, or court shall proceed in respect thereto as authorized by law in the case of crimes or misdemeanors committed against the United States.

Amendment.

SEC. 3. That the right to alter, amend, or repeal this Act at any time is hereby reserved.

Pending actions unaffected.

SEC. 4. That this Act shall not, nor shall any rules or regulations prescribed thereunder, in any manner affect any civil action or actions heretofore commenced and now pending to recover damages claimed to have been sustained by reason of the violation of any of the terms of said section fifteen, as originally enacted, or in violation of any other law.

Approved, May 9, 1900.

May 10, 1900.

CHAP. 388.—An Act To authorize the construction of a bridge across the Back Bay, at Biloxi, Mississippi.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

Biloxi, Miss., may bridge Back Bay, etc.

That the mayor and board of aldermen of the town of Biloxi, in the State of Mississippi, be, and hereby are, authorized to construct and maintain a bridge and approaches thereto across the bay, commonly known as the Back Bay, at or near the town of Biloxi, Mississippi, between the said town of Biloxi, situated on the south side of said bay, to a point on the north side of said bay, said bridge to start at or near what is known as the old ferry point, on the south shore of said bay, running thence north twenty-two degrees east to the south side of the channel or to the marsh; thence north nineteen degrees east to mainland, or said location to be selected consistent with the interests of navigation.

Transit; toll.

Said bridge shall be built to provide for the passage of wagons and vehicles of all kinds, and animals, and for all road travel, for such reasonable rates of toll and under such reasonable rules and regulations as may be prescribed by the said parties, or their successors and assigns, and to be approved from time to time by the Secretary of War.

Secretary of War to approve plans, etc.

SEC. 2. That said bridge shall not be commenced or built until the plans and specifications for its construction have been submitted to the Secretary of War for his approval, nor until he shall approve the plan and location of said bridge;

Changes.

and if any change be made in the plan or construction of said bridge at any time, such change shall be subject to the approval of the Secretary of War; and any change in the construction or any alteration of said bridge that may be directed at any time by Congress or the Secretary of War shall be made at the cost and expense of the owners thereof;

No obstruction to navigation.

that said bridge shall be constructed without interference with the security and convenience of navigation of said bay beyond what is necessary to

carry out effectually the rights and privileges hereby granted, and in order to secure that object the said parties shall submit to the Secretary of War for his examination and approval a design of and drawings of said bridge and accessory works and a map of the proposed location, giving, for the space of three hundred yards above and below such proposed location, the topography of the banks of the bay, with shore lines and soundings and directions of currents at medium high-tide water, and such other information as may be required for a full understanding of the subject.

Draw.

SEC. 3. That said bridge shall be built as a low bridge, and shall have one drawspan of such width of openings as may be prescribed by the Secretary of War, which drawspan shall be maintained over the main channel of said bay at an accessible and navigable point, and the piers of said bridge at said channel shall be parallel with, and the bridge itself at right angles to, the current of said channel. Said drawspan shall be opened promptly by said parties or their successors and assigns, upon reasonable signal, for the passage of boats and rafts: *Provided*, That the said parties, or their successors and assigns, shall, at their own expense, under the direction and supervision of the Secretary of War, when so required, do and perform such necessary work to maintain the channel within the drawspan of said bridge, and shall, at their own expense, maintain a depth of water through said span not less than now existing, as shown by the records of the War Department: *And provided further*, That said parties, or their successors and assigns, shall maintain, at their own expense, from sunset to sunrise, such lights or other signals on said bridge as the Light-House Board shall prescribe.

Provisos.
Maintenance of channel.

Lights.

To be lawful structure and post route.

SEC. 4. That any bridge built under this Act and subject to its limitations shall be a lawful structure, and shall be recognized and known as a post route, upon which also no higher charge shall be made for the transmission over the same of the mails, the troops and munitions of war of the United States than the rate per mile for the transportation over the public highways leading to the said bridge, and it shall enjoy the rights and privileges of other post roads in the United States.

Amendment.
Removal of obstructions, etc.

SEC. 5. That Congress reserves the right to alter, amend, or repeal this Act, and the Secretary of War, whenever he shall deem it necessary, may cause the owners of said bridge to remove all material and substantial obstructions to the navigation of said bay by the construction of said bridge and its accessory works, or to prevent such obstructions; and the expense of altering said bridge and removing such obstructions shall be at the expense of the owners of the bridge.

Commencement and completions.

SEC. 6. That this act shall be null and void if construction of said bridge shall not be commenced within one year and completed within three years from its approval.

Approved, May 10, 1900.

May 25, 1900.

CHAP. 552.—An Act Making appropriations for fortifications and other works of defense, for the armament thereof, for the procurement of heavy ordnance for trial and service, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the sums of money herein provided for be, and the same are hereby, appropriated, out of any moneys in the Treasury not otherwise appropriated, to be available until expended, namely:

Fortifications appropriations.

Fortifications.

FORTIFICATIONS AND OTHER WORKS OF DEFENSE.

Gun and mortar batteries.

For construction of gun and mortar batteries, two million dollars.

Pneumatic dynamite batteries.

For pneumatic dynamite batteries, one hundred and eighty thousand dollars.

Ranges, etc., finders.

For installation of range and position finders, one hundred and fifty thousand dollars.

Sites.

For the procurement of land, or right pertaining thereto, needed for the site, location, construction, or prosecution of works, for fortifications and coast defenses, two hundred thousand dollars.

Sullivans Island, S. C.

For the purchase of suitable building sites, and improvements and leases thereon, necessary to properly provide for the garrison at Sullivans Island, Charleston, South Carolina, one hundred and thirty-five thousand dollars, or so much thereof as may be necessary: *Provided*, That no part of this sum shall be expended until valid title to all the land, and improvements and leases thereon, necessary for this purpose shall have been acquired by the United States.

Proviso. legal title.

Repairs.

For the protection, preservation, and repair of fortifications for which there may be no special appropriation available, one hundred thousand dollars.

Plans.

For preparation of plans for fortifications, five thousand dollars.

Electric light, etc., plants.

For tools, electrical and engine supplies, for use of the troops for maintaining and operating electric light and power plants in gun and mortar batteries, twenty-five thousand dollars.

Sea walls, etc.

For construction of sea walls and embankments, fifty thousand dollars.

Fort Caswell, N. C.

For construction of a sea wall and for necessary filling in at the reservation at Fort Caswell, North Carolina, one hundred and fifty thousand dollars.

Mines, etc.

For the purchase of submarine mines and necessary appliances to operate them for closing the channels leading to our principal seaports, needful casemates, cable galleries, and so forth, to render it possible to operate submarine mines, and continuing torpedo experiments, fifty thousand dollars.

* * * * *

Board of Ordnance and Fortification.

BOARD OF ORDNANCE AND FORTIFICATION.

* * * * *

That all material purchased under the foregoing provisions of this Act shall be of American manufacture, except in cases when, in the judgment of the Secretary of War, it is to the manifest interest of the United States to make purchases in limited quantities abroad, which material shall be admitted free of duty.

Purchases to be of American manufacture.—exception.

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Approved, May 25, 1900.

CHAP. 554.—An Act To provide for the construction of a bridge by the Duluth, Pierre and Black Hills Railroad Company across the Missouri River at Pierre, South Dakota.

May 25, 1900.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Duluth, Pierre and Black Hills Railroad Company, a corporation duly organized under the general incorporation laws of the State of South Dakota, its successors and assigns, is hereby authorized to construct and maintain a bridge across the Missouri River at or near the city of Pierre, Hughes County, South Dakota, and also to lay on and over said bridge a railway track or tracks for the passage of railway trains; and said corporation may construct and maintain ways for wagons, carriages, and foot passengers, charging and receiving such reasonable tolls therefor as may be approved from time to time by the Secretary of War.

Duluth, Pierre and Black Hills Railroad may bridge Missouri River at Pierre, S. Dak.

Transit; tolls.

SEC. 2. That said bridge should be constructed and built without interference with the security and convenience of navigation of said river beyond what is necessary to carry into effect the rights and privileges hereby granted; and in order to secure that object the said corporation shall submit to the Secretary of War, for his examination and approval, a design and drawings of the bridge, and a map of the location, giving, for the space of one mile above and one mile below the proposed location, the topography of the banks of the river, the shore lines at high and low water, the direction and strength of the currents at all stages, and the soundings accurately showing the bed of the stream, the location of any other bridge or bridges, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until the said plan and location of the bridge are approved by the Secretary of War, the bridge shall not be built: *Provided*, That if the said bridge shall be made with unbroken and continuous spans it shall not be of less elevation in any case than fifty feet above extreme high-water mark as understood at the point of location to the lowest part of the superstructure of the bridge, nor shall the spans of said bridge be less than three hundred feet in length in the clear; and the piers of said bridge shall be parallel with the current of said river, and the bridge itself at right angles thereto, and the main span shall be over the main channel of the river and not less

Not to obstruct navigation.

Secretary of War to approve plans.

Provisos.

Elevation, etc.

than three hundred feet in length in the clear: *And provided also*, That if any bridge built under this Act shall be constructed as a drawbridge the same shall be constructed as a pivot drawbridge, with a draw over the main channel of the river at an accessible and navigable point and with spans of not less than two hundred feet in length in the clear on each side of central or pivot pier of the draw, and the next adjoining span or spans to the draw shall not be less than three hundred feet, and the headroom under all river spans shall not be less than ten feet above local high-water mark, and the piers of said bridge shall be built with the current of said river and the bridge itself at right angles thereto: *Provided also*, That said draw shall be opened promptly upon the reasonable signal for the passing of boats; and said company or corporation shall maintain, at its own expense, from sunset till sunrise such lights or other signals on said bridge as the Light-House Board shall prescribe: *Provided also*, That said company shall, at its own expense, build and maintain, under direction and supervision of the Secretary of War, such wing dams and booms or other works necessary to maintain the channel within the draw spans of said bridge, and shall, at their own expenses, maintain a depth of water through said draw spans not less than that now existing, as shown by the report of the War Department, at the point where said bridge may be located: *Provided also*, That all railway companies desiring to use said bridge shall have and be entitled to equal rights and privileges in the passage of the same, and in the use of the machinery and fixtures thereof, and of all the approaches thereto, under and upon such terms and conditions as shall be prescribed by the Secretary of War, upon hearing the allegations and proofs of the parties, in case they shall not agree.

Draw.

—opening of.

Lights.

Maintenance of channel, etc.

Rights of railroads to use.

Notification of approval.

SEC. 3. That the Secretary of War is hereby authorized and directed, upon receiving such plan and map and other information, and upon being satisfied that the bridge built upon such plan, with such accessory works, and at such locality, will conform to the prescribed conditions of this Act, to notify the company that he approves the same; and upon receiving such notification the said company may proceed to an erection of said bridge, conforming strictly to the approved plan and location; and should any change be made in the plan of the bridge or accessory works during the progress of the work thereon, such change shall be subject likewise to the approval of the Secretary of War; and if any bridge erected under said authority shall, in the opinion of the Secretary of War, obstruct such navigation, he is hereby authorized to cause such change or alteration of said bridge to be made as will effectually obviate such obstruction, and all such alterations shall be made and all such obstructions be removed at the expense of the said corporation; and in case of any litigation arising from any obstruction, or alleged obstruction, to the free navigation of said river, caused, or alleged to be caused, by said bridge, the case

Changes.

Litigation.

may be brought in any court of the United States of the State of South Dakota in which any portion of said bridge may be located: *Provided*, That nothing in this Act shall be so construed as to repeal or modify any of the provisions of law now existing in reference to the protection of the navigation of rivers, or to exempt this bridge from the operation of the same: *Provided further*, That this bridge shall not be opened to traffic until all piling and other false work used in constructing the bridge shall have been wholly removed to the satisfaction of the Secretary of War.

Provisos. Existing law unaffected.

Removal of piling, etc.

SEC. 4. That the said bridge and accessory works, when built and constructed under this Act, and according to the terms and limitations thereof, shall be lawful structures, and said bridge shall be recognized and known as a post route, upon which also no higher charge shall be made for the transmission over the same of the mails, the troops, and the munitions of war of the United States than the rate per mile paid for the transportation over the railroads or public highways leading to such bridge; and said bridge shall enjoy the rights and privileges of other post routes of the United States, and Congress reserves the right at any time to regulate by appropriate legislation the charges for freight and passengers over said bridge.

To be lawful structure and post route.

Freight, etc., charges.

SEC. 5. That the United States shall have the right of way for such postal telegraph lines across said bridge as the Government may construct or control.

Government postal telegraph lines.

SEC. 6. That this Act shall be null and void if actual construction of the bridge herein authorized be not commenced within two years and completed within four years from the date of approval thereof.

Commencement and completion.

SEC. 7. That Congress reserves the right to alter, amend, or repeal this Act at any time.

Amendment.

Approved, May 25, 1900.

May 26, 1900.

CHAP. 586.—An Act Making appropriation for the support of the Regular and Volunteer Army for the fiscal year ending June thirtieth, nineteen hundred and one.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums be, and they are hereby, appropriated, out of any money in the Treasury not otherwise appropriated, for the support of the Army for the year ending June thirtieth, nineteen hundred and one:

Army appropriations.

* * * * *

MISCELLANEOUS.

* * * * *

For additional pay to officer in charge of public buildings and grounds at Washington, District of Columbia, one thousand dollars.

Additional pay, officer in charge of public buildings, D. C.

* * * * *

Mileage to officers. *Provisos.* —limit.

For mileage to officers and contract surgeons, when authorized by law, five hundred thousand dollars: *Provided*, That officers so traveling shall be paid seven cents per mile and no more; distances to be computed and mileage to be paid over the shortest usually traveled routes, with deduction as hereinafter provided; and payment and settlement of mileage accounts of officers shall be made according to distances computed over routes established and by mileage tables prepared by the Paymaster-General of the Army under the direction of the Secretary of War; and all payments made by paymasters on account of mileage previous to the passage of this Act shall be settled in accordance with distance tables officially promulgated and in use at date of payment: *Provided further*, That officers who so desire may, upon application to the Quartermaster's Department, be furnished with transportation requests, exclusive of sleeping and parlor car accommodations, for the entire journey under their orders; and the transportation so furnished shall be a charge against the officer's mileage account, to be deducted at the rate of three cents per mile by the paymaster paying the account, the amount so deducted to be turned over to an authorized officer of the Quartermaster's Department for the credit of the appropriation for transportation of the Army and its supplies: *And provided further*, That when the established route of travel shall, in whole or in part, be over the line of any railroad on which the troops and supplies of the United States are entitled to be transported free of charge, or over any of the bond-aided Pacific railroads, or over the railroad of any railroad company which by law or agreement is entitled to receive only fifty per centum of the compensation earned by such company for transportation services rendered the United States, officers traveling as herein provided for shall, for the travel over such roads, be furnished with transportation requests, exclusive of sleeping and parlor car accommodations, by the Quartermaster's Department: *And provided further*, That when transportation is furnished by the Quartermaster's Department, or when the established route of travel is over any of the railroads above specified, there shall be deducted from the officer's mileage account by the paymaster paying the same three cents per mile for the distance for which transportation has been or should have been furnished: *And provided further*, That actual expenses only shall be paid to officers for sea travel when traveling, as herein provided for, to, from, or between our island possessions: *Provided also*, That hereafter when an officer shall be discharged from the service, except by way of punishment for an offense, he shall receive for travel allowances from the place of his discharge to the place of his residence at the time of his appointment or to the place of his original muster into the service, four cents per mile; and an enlisted man, when discharged from the service, except by way of punishment for an offense, shall receive four cents per mile from the place of his discharge to the place of his enlistment, enrollment, or orig-

Settlement of mileage accounts.

Transportation requests.

Travel on bond-aided, etc., railroads, etc.

Fifty per centum railroads.

Deduction.

Actual expenses to island possessions.

Travel allowance on discharge.

inal muster into the service: *Provided further*, That for sea travel on discharge, to, from, or between our island possessions, actual expenses only shall be paid to officers and transportation and subsistence only shall be furnished to enlisted men.

Sea travel on discharge to island possessions, etc.

* * * * *

ENGINEER DEPARTMENT.

Engineer Department.

ENGINEER DEPOT AT WILLETS POINT, NEW YORK: For incidental expenses of the depot, including fuel, lights, chemicals, stationery, hardware, extra-duty pay to soldiers necessarily employed for periods not less than ten days as artificers on work in addition to and not strictly in the line of their military duties, such as carpenters, blacksmiths, draftsmen, printers, lithographers, photographers, engine drivers, teamsters, wheelwrights, masons, machinists, painters, overseers, laborers, repairs of, and for materials to repair, public buildings, machinery, and unforeseen expenses, five thousand dollars.

Incidental expenses

For the purchase of material for use of United States Engineer School and for instruction of engineer troops at Fort Totten, Willets Point, in their special duties as sappers and miners, for land and submarine mines, pontoniers, torpedo drill, and signaling, one thousand five hundred dollars.

Materials.

For purchase and repair of instruments, to be issued to officers of the Corps of Engineers and to officers detailed and on duty as acting engineer officers, for use on public works and surveys, three thousand dollars.

Instruments

For purchase and binding of professional works of recent date treating of military and civil engineering and kindred scientific subjects, for library of the United States Engineering School, five hundred dollars.

Library.

For pontoon trains, intrenching tools, instruments, and drawing materials, twenty-five thousand dollars.

Tools, etc.

For services of surveyors, draftsmen, photographers, clerks to engineer officers on the staff of division, corps, and department commanders, twenty-five thousand dollars.

Surveyors, etc.

Total for Engineer Department, sixty thousand dollars.

Amount.

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Approved, May 26, 1900.

CHAP. 619.—An Act Authorizing the construction of a bridge across the Red River of the North.

June 4, 1900.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Cooper Pontoon Bridge Company, of Walsh County, State of North Dakota, a corporation organized under the laws of the State of North Dakota, be, and is hereby, authorized to construct and maintain a pontoon bridge and approaches thereto across the Red River of the North between the State of Minnesota and the State

Cooper Pontoon Bridge Company may bridge Red River of the North.

Location.

of North Dakota, extending from a point on said river where the section line running east and west between sections eight and seventeen, township one hundred and fifty-seven north, of range fifty west, in Marshall County, State of Minnesota, intersects said river, to a point opposite in the State of North Dakota. Said bridge shall be constructed so as to provide for the passage of wagons and vehicles of all kinds, animals, and foot passengers, and for road travel, for such reasonable rates of toll and under such rules and regulations as may be prescribed by said corporation and approved from time to time by the Secretary of War.

Toll.

To be lawful structure and post route.

SEC. 2. That any bridge built under this Act and subject to its limitations shall be a lawful structure, and shall be recognized and known as a post route, upon which also no higher charge shall be made for the transmission over the same of the mails, the troops, and the munitions of war of the United States than the rate per mile paid for transportation over railroads or public highways leading to the said bridge; and it shall enjoy the rights and privileges of other post roads in the United States, and the United States shall have the right of way across said bridge and its approaches for postal-telegraph purposes. And equal rights as to constructing and maintaining their lines over said bridge shall be granted to all telephone and telegraph companies desiring to use the same.

Telegraph etc., companies.

Draw.

SEC. 3. That said bridge shall be constructed as a pontoon drawspan bridge, and shall contain a pontoon drawspan of such dimensions as the Secretary of War shall prescribe, which said drawspan shall be maintained on the main channel of the river at an accessible and navigable point; and the piers shall be parallel with, and the bridge itself at right angles to, the current of the river: *Provided*, That said draw shall be opened promptly, upon reasonable signal, for the passage of boats and rafts; and said corporation shall maintain at its own expense, from sunset to sunrise, such lights or other signals on said bridge as the Light-House Board shall prescribe. No bridge shall be constructed or maintained under the authority of this Act which shall at any time substantially or materially obstruct the free navigation of said river; and if any bridge erected under said authority shall, in the opinion of the Secretery of War, obstruct such navigation, he is hereby authorized to cause such change or alteration of said bridge to be made as will effectually obviate such obstruction, and all such alterations shall be made and all such obstructions be removed at the expense of the said corporation; and in case of any litigation arising from any obstruction or alleged obstruction to the free navigation of said river, caused or alleged to be caused by said bridge, suit may be brought in any circuit court of the United States for the circuit in which said bridge or any part thereof is located to remove or remedy the same: *Provided further*, That nothing in this Act shall be construed as to repeal or modify any of the provisions of law now existing in reference to the protection of the naviga-

Proviso. —opening of.

Lights.

Bridge not to obstruct navigation.

Litigation.

Existing law unaffected.

tion of rivers, or to exempt this bridge from the operations of the same.

SEC. 4. That any bridge authorized to be constructed under this act shall be built and located under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe; and to secure that object the said corporation shall submit to the Secretary of War, for his examination and approval, a design and drawings of the said bridge and a map of the location, giving, for the space of one-half mile above and one-half mile below the proposed location, the high and low water lines upon the banks of the river, the direction and strength of the current at all stages, with the soundings, accurately showing the bed of the stream, and the location of any other bridge or bridges, such map to be sufficiently in detail to enable the Secretary of War to judge of the proper location of said bridge, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject; and until such plan and location of the bridge are approved by the Secretary of War the bridge shall not be built; and should any change be made in the plan of said bridge, during the progress of construction or after completion, such change shall be subject to the approval of the Secretary of War. Secretary of War to approve plans, etc. —changes.

SEC. 5. That the right to alter, amend, or repeal this Act is hereby expressly reserved. Amendment.

SEC. 6. That this act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year and completed within three years from the date of the approval of this act. Commencement and completion.

Approved, June 4, 1900.

June 4, 1900.

CHAP. 620.—An Act Permitting building a dam across New River.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the consent of Congress is hereby granted to F. H. Fries and W. C. Ruffin, of the State of North Carolina, their successors and assigns, to erect, construct, and maintain across New River, in Grayson County, Virginia, at any point within two miles of the mouth of Stevens Creek, a dam and all other works necessarily incident thereto for water-power purposes: *Provided*, That the said F. H. Fries and W. C. Ruffin, their successors and assigns, shall make, at their own expense, such change and modification of the said dam as the Secretary of War may from time to time direct in the interests of the navigation of said river: *Provided further*, That ladders suitable for the passage of fish over the said dam shall be constructed and maintained by the said parties, their successors and assigns, as may from time to time be required by the United States Fish Commissioner: *Provided further*, That in case any litigation arises from the obstruc- F. H. Fries et al. may dam New River, Va. *Provisos.* —changes. Passage of fish. Litigation.

tion of the channel by the said dam, or works appurtenant thereto, that the same may be tried in the courts of the United States having proper jurisdiction.

Commencement and completion.

SEC. 2. That this Act shall become null and void unless the dam herein authorized shall be commenced within two years and completed within five years of the date hereof.

Amendment.

SEC. 3. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

Approved, June 4, 1900.

June 6, 1900.

CHAP. 779.—An Act To amend an Act granting to the Muscle Shoals Power Company right to erect and construct canal and power stations at Muscle Shoals, Alabama.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

Muscle Shoals Power Company canal and power stations. Vol. 30, p. 1351.

That section two of an act entitled "An act granting to the Muscle Shoals Power Company right to erect and construct canal and power stations at Muscle Shoals, Alabama," approved March third, eighteen hundred and eighty-nine, be, and the same is hereby, amended so as to read as follows:

Time extended to complete work.

"SEC. 2. That unless the work herein authorized be commenced within two years, and completed within four years from the date hereof, the privileges hereby granted shall cease and be determined."

Approved, June 6, 1900.

June 6, 1900.

CHAP. 782.—An Act To authorize the construction of a railroad bridge across the Mississippi River at Saint Paul, Minnesota.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

South St. Paul Belt Railroad may bridge Mississippi River.

That the South Saint Paul Belt Railroad Company, a corporation duly organized and incorporated under the laws of the State of Minnesota, its successors and assigns, be, and is hereby, authorized to construct and maintain a bridge for the passage of railroad traffic, and also, at the option of the said railroad company, for the passage of vehicles of all kinds, animals, and foot passengers, across

Location.

the Mississippi River at a point suitable to the interests of navigation, and between the crossing of the south line of section four of township twenty-eight, range twenty-two, and the crossing of the north and south center line of section five of the same township, and within the incorporated limits of the city of Saint Paul, Minnesota; that the location and plan of construction of said bridge shall be

Secretary of War to approve plans.

subject to the approval of the Secretary of War, and until decided by him to be such as will not materially affect the interests of navigation the said bridge shall not be built. And there shall be submitted to the Secretary of War, for his examination and approval, a plan of the proposed bridge and a map of the location thereof, giv-

ing, for a distance of a mile above and below the proposed location, the topography of the banks of the river, the shore line at high and low water, the direction of the current, and soundings accurately showing the bed of stream, and the location of any other bridge or bridges; and should any change be made in the plan of said bridge during the progress of construction, such change shall be subject to the approval of the Secretary of War; and the said bridge shall at all times be so kept and maintained, and provided with protection piers and sheer booms, so as to offer reasonable and proper means for the passage of vessels and other floating craft through or under said structure; and for the safety of vessels passing at night there shall be displayed on said bridge, from the hours of sunset to sunrise, such lights as may be prescribed by the Light-House Board; and the said structure shall be changed, at the cost and expense of the owners thereof, from time to time, as the Secretary of War may direct, and as may be necessary to preserve the free and convenient navigation of said river. That said bridge shall not interfere with the free navigation of said river beyond what is necessary in order to carry into effect the rights and privileges hereby granted; and in case of any litigation arising from any obstruction, or alleged obstruction, to the said free navigation of said river, the cause may be tried before the circuit court of the United States in and for the district in which the said bridge is located: *Provided*, That nothing herein contained shall be construed as repealing or modifying any of the provisions of law now existing in reference to the protection of the navigation of rivers, or as exempting this bridge from the operations of the same.

Aids to navigation.

Lights.

Changes.

Not to obstruct navigation.

Litigation.

Proviso.
Existing provisions of law unchanged, etc.

SEC. 2. That said bridge shall be constructed either as a high-level bridge without a drawspan, or a low-level bridge with a drawspan, as the said railroad company may elect. If constructed as a high-level bridge, the main span over the navigable channel of the river shall be of such length as will give a clear width of waterway at low-water level of not less than three hundred and fifty feet, and a clear headroom under the full length of said span of not less than fifty-five feet above extreme high-water level; if constructed as a low-level bridge, there shall be a drawspan with openings under each arm thereof, giving such clear widths of waterway, not less than one hundred and eighty feet each, as in the opinion of the Secretary of War are required by the interests of navigation; the remaining spans, if either of a high or low level bridge, shall each give a clear width of waterway not less than one hundred and fifty feet at the low-water level of the river, and a clear headroom not less than ten feet above extreme high-water mark.

Draw.

SEC. 3. That said South Saint Paul Railroad Company shall have the right to charge and collect a reasonable rate of toll for the passage across said bridge of all railroad and other vehicles, animals, and foot passengers, subject to approval of Secretary of War: *Provided*,

Toll.

Proviso.

Rights of railroads to use.

That all railroad companies desiring the use of said bridge shall have and be entitled to equal rights and privileges relative to the passage of trains or cars over the same and over the approaches thereto upon the payment of a reasonable compensation for such use; and in case the owner or owners of such bridge and the several companies, or any one of them, desiring such use shall fail to agree upon the sum or sums to be paid, and upon the rules and conditions to which each shall conform in using said bridge, all matters at issue between them shall be decided by the Secretary of War upon a hearing of the allegations and proofs of the parties; and equal privileges in the use of said bridge shall be granted to all telegraph and telephone companies.

Commencement and completion.

SEC. 4. That this Act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year and completed within three years of the date of approval thereof.

To be lawful structure and post route.

SEC. 5. That the bridge built under this Act and subject to its limitations shall be a lawful structure, and shall be known and recognized as a post route upon which also no higher charge shall be made for the transportation over the same of the mail, the troops and munitions of war of the United States than the rates per mile paid for transportation over railroads or public highways leading to the said bridge, and it shall enjoy the rights and privileges of other post roads in the United States.

Amendment.

SEC. 6. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

Approved, June 6, 1900.

June 6, 1900.

CHAP. 783.—An Act To authorize the Alexandria and Pineville Bridge Company to build and maintain a traffic bridge across Red River at the town of Alexandria, in the parish of Rapides, State of Louisiana.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

Alexandria and Pineville Bridge Company may bridge Red River at Alexandria, La.

That the Alexandria and Pineville Bridge Company, a corporation duly incorporated and existing under and by virtue of the laws of the State of Louisiana, be, and is hereby, authorized to construct and maintain a traffic bridge across Red River at a point suitable to the interest of navigation, within the corporate limits of the town of Alexandria, in the parish of Rapides, State of Louisiana.

Transit.

Said bridge shall be constructed to provide for the passage of vehicles, street-railway cars, foot passengers, stock, and such other traffic as may be desired, at such legal rates of toll as may be fixed by said company, and approved by the Secretary of War.

Toll.

To be lawful structure and post route.

SEC. 2. That said bridge built under this Act, and subject to its limitations, shall be a lawful structure, and shall be recognized and known as a post route, upon which also no higher charge shall be made for the transmission over the same of the mails, the troops, and munitions of

war of the United States than the rate paid for the transmission over the public highways leading to the said bridge, and shall enjoy the rights and privileges of other post roads in the United States; and equal privileges in the use of said bridge shall be granted to all telegraph and telephone companies; and the United States shall have the right of way across said bridge and its approaches for postal-telegraph purposes: *Provided*, That the bridge herein authorized to be constructed shall be so kept and managed by the company owning or operating it as to afford proper ways and means for the passage through or under it of vessels, barges, or rafts at all times, both by day and by night; and if said bridge be constructed as a drawbridge, the draw shall be opened promptly upon reasonable signal for the passage of boats; and upon whatever kind of bridge is built there shall be displayed from sunset to sunrise, at the expense of said company, such lights and signals as the Light-House Board shall prescribe.

Telegraph, etc. companies.

Proviso. Aids to navigation.

Draw.

Lights.

SEC. 3. That if said bridge, erected and maintained under the authority of this Act, shall at any time substantially or materially obstruct the free navigation of said river, or shall, in the opinion of the Secretary of War, obstruct such navigation, he is hereby authorized to cause such change or alteration of said bridge to be made as will effectually obviate such obstruction; and such alteration shall be made and all such obstructions be removed at the expense of the owners or operators of said bridge; and in case of any litigation arising from the obstruction or alleged obstruction to the free navigation of said river, the case may be brought in the district court of the United States for the western district of Louisiana: *Provided*, That nothing in this Act shall be so construed as to repeal or modify any of the provisions of law now existing in reference to the protection of the navigation of rivers, or to exempt said bridge from the operation of same.

Changes.

Litigation.

Proviso. Existing law unaffected.

SEC. 4. That the bridge authorized to be constructed under this Act shall be built and located under and subject to such regulations for the security of navigation of said river as the Secretary of War shall prescribe; and to secure that object the said company or corporation shall submit to the Secretary of War, for his examination and approval, a design and drawing of said bridge, and a map of the location, prepared with reference to known datum plane upon prescribed scales furnished by the engineer officer having supervision of said river, and giving, for the space of two miles above and two miles below the proposed location of the bridge, the topography of the banks of the river, with shore lines at high and low water, the direction and strength of the currents at all stages, and the soundings accurately showing the bed of the stream, the location of any other bridge or bridges, and shall furnish such other information as may be required for a full and satisfactory understanding of the subject. And until said plans and location of the bridge are approved by the Secretary of War the bridge shall not be

Secretary of War to approve plans.

built; and should any change be made in the plan of the said bridge during the process of construction, or after completion, such change shall be subject to the approval of the Secretary of War.

Commencement and completion.

SEC. 5. That this Act shall be null and void if actual construction of the bridge herein authorized be not commenced within one year and completed within three years from the date of the approval hereof.

Amendment.

SEC. 6. That the right to alter, amend, or repeal this Act is hereby expressly reserved.

Approved, June 6, 1900.

June 6, 1900.

CHAP. 785. An Act Making appropriations to supply deficiencies in the appropriations for the fiscal year ending June thirtieth, nineteen hundred, and for prior years, and for other purposes.

Deficiencies appropriations.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums be, and the same are hereby, appropriated, out of any money in the Treasury not otherwise appropriated, to supply deficiencies in the appropriations for the fiscal year nineteen hundred, and for prior years, and for other objects hereinafter stated, namely:

* * * * *

Treasury Department.

TREASURY DEPARTMENT.

Contingent expenses.

CONTINGENT EXPENSES.

* * * * *

Corps of Engineers. Credit in accounts of certain officers.

CREDIT IN ACCOUNTS OF CERTAIN OFFICERS, CORPS OF ENGINEERS: Authority is hereby granted to the proper accounting officers of the Treasury to allow and credit in the accounts of certain officers of the Corps of Engineers of the United States Army amounts standing against them on the books of the Treasury as follows: Captain William E. Craighill, sixteen dollars and thirty cents; Captain C. H. McKinstry, forty-five dollars; Captain H. C. Newcomer, two hundred and forty-six dollars and eighty-eight cents; Major Charles W. Raymond, sixty-one dollars and forty-eight cents; Major Thomas L. Casey, twenty-one dollars and thirty-two cents; Major H. M. Adams, two thousand six hundred and sixteen dollars and forty cents; Major E. H. Ruffner, forty dollars and eighty cents; Major R. L. Hoxie, forty-four dollars and sixty-seven cents; Major C. McD. Townsend, thirty-one dollars and ninety-two cents; Major W. H. Bixby, one hundred and sixty-eight dollars and fifty-six cents; Major Charles F. Powell, fifty-six dollars and thirty cents; Lieutenant-Colonel Charles J. Allen, nine dollars and eighty-eight cents; and Lieutenant-Colonel W. A. Jones, two hundred and eighty-eight dollars and fifty-one cents; in all, three thousand six hundred and forty-seven dollars and two cents.

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WAR DEPARTMENT.

War Department.

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MILITARY ESTABLISHMENT.

Military establishment.

* * * * *

To pay amounts found due by the accounting officers of the Treasury on account of the appropriation "Improving Wicomico River, Maryland," eighteen dollars.

Wicomico River, Md.

To pay amounts found due by the accounting officers of the Treasury on account of the appropriation "Improvement of Yellowstone National Park," six dollars and ninety-five cents.

National parks. —Yellowstone.

* * * * *

BUILDINGS AND GROUNDS IN AND AROUND WASHINGTON.

Buildings and grounds, District of Columbia.

For reimbursement of the sculptor for the Sherman statue for extra and unforeseen expenses connected with the subfoundation of said statue, of which the pedestal has already been completed in accordance with the contract therefor, nine thousand five hundred and fifty-five dollars and five cents, to be disbursed by the officer in charge of public buildings and grounds, under the direction of the Sherman statue commission.

Sherman statue. —reimbursement of sculptor.

For removal of present iron fence around the site of the Sherman statue and setting up of a substantial granite curb in place thereof, eight thousand dollars, or so much thereof as may be found necessary, to be expended by the officer in charge of public buildings and grounds, under the direction of the Sherman statue commission.

—removal of fence.

* * * * *

CLAIMS ALLOWED BY THE AUDITOR FOR THE WAR DEPARTMENT.

Claims allowed by the Auditor for the War Department.

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For contingencies of fortifications, fifty-four dollars and seventy-nine cents.

Fortifications

* * * * *

Approved, June 6, 1900.

CHAP. 786.—An Act Making further provision for a civil government for Alaska, and for other purposes.

June 6, 1900.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

TITLE I.

CHAPTER ONE.

* * * * *

SEC. 26. The laws of the United States relating to mining claims, mineral locations, and rights incident thereto

Mining laws.

Provisos. Gold, etc., explorations on Bering Sea.

are hereby extended to the District of Alaska: *Provided*, That subject only to such general limitations as may be necessary to exempt navigation from artificial obstructions all land and shoal water between low and mean high tide on the shores, bays, and inlets of Bering Sea, within the jurisdiction of the United States, shall be subject to exploration and mining for gold and other precious metals by citizens of the United States, or persons who have legally declared their intentions to become such, under

—miners' regulations

such reasonable rules and regulations as the miners in organized mining districts may have heretofore made or may hereafter make governing the temporary possession thereof for exploration and mining purposes until other-

—not to conflict with federal laws.

wise provided by law: *Provided further*, That the rules and regulations established by the miners shall not be in conflict with the mining laws of the United States; and

Exclusive permits to mine void, etc.

no exclusive permit shall be granted by the Secretary of War authorizing any person or persons, corporation or company to excavate or mine under any of said waters below low tide, and if such exclusive permit has been granted it is hereby revoked and declared null and void; but citizens of the United States or persons who have legally declared their intention to become such shall have the right to dredge and mine for gold or other precious metals in said waters, below low tide, subject to such general rules and regulations as the Secretary of War may prescribe for the preservation of order and the protection of the interests of commerce; such rules and regulations shall not, however, deprive miners on the beach of the right hereby given to dump tailings into

Provision reserving roadway, etc., not to apply. Vol. 30, p. 413.

or pump from the sea opposite their claims, except where such dumping would actually obstruct navigation, and the reservation of a roadway sixty feet wide, under the tenth section of the Act of May fourteenth, eighteen hundred and ninety-eight, entitled "An Act extending the homestead laws and providing for right of way for railroads in the District of Alaska, and for other purposes," shall not apply to mineral lands or town sites.

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Approved, June 6, 1900.

June 6, 1900.

CHAP. 789.—An Act Making appropriations to provide for the expenses of the government of the District of Columbia for the fiscal year ending June thirtieth, nineteen hundred and one, and for other purposes.

District of Columbia. Appropriations. Half from District revenues.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the half of the following sums named, respectively, is hereby appropriated, out of any money in the Treasury not otherwise appropriated, and the other half out of the revenues of the District of Columbia, for the purposes following, being for the expenses of the government of

the District of Columbia for the fiscal year ending June thirtieth, nineteen hundred and one, namely:

GENERAL EXPENSES.

General expenses.

FOR EXECUTIVE OFFICE: For two Commissioners, at five thousand dollars each; Engineer Commissioner, one thousand seven hundred and sixty-eight dollars (to make salary five thousand dollars);

Executive office. Commissioners, secretary, etc.

*   *   *   *   *

PERMANENT SYSTEM OF HIGHWAYS.

To pay the expenses of carrying out the plan for the extension of a permanent system of highways in conformity with the "Act to provide a permanent system of highways in that part of the District of Columbia lying outside of cities," approved March second, eighteen hundred and ninety-three, two thousand five hundred dollars; to be paid wholly out of the revenues of the District of Columbia.

Extension of highways. Vol. 27, p. 532.

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BRIDGES.

Bridges.

For ordinary care of bridges, including keepers, oil, lamps, and matches, four thousand dollars.

Care.

For construction and repair of bridges, fifteen thousand dollars.

Repairs.

For continuing the construction of a bridge across Rock Creek on the line of Massachusetts avenue extended, fifty thousand dollars: *Provided*, That the Commissioners of the District of Columbia are hereby authorized to purchase or condemn so much of the land within the lines of Massachusetts avenue extended to which the District does not now possess title, and such adjacent land for side slopes, embankments, and so forth, as may be necessary, and to use for such purpose so much of the sum hereby appropriated as may be necessary; and the proceedings for condemnation, if the same be necessary, shall be in accordance with the provisions relating to the condemnation of land as contained in section three of the Act approved August thirtieth, eighteen hundred and ninety, entitled "An Act making appropriations for sundry civil expenses of the Government for the fiscal year ending June thirtieth, eighteen hundred and ninety-one, and for other purposes;" and the Commissioners of the District of Columbia, upon the confirmation by the court of the award of the commissioners appointed to appraise the land to be taken, and after payment into said court of the amount thereof, may enter upon said land and proceed with the construction of said bridge, notwithstanding any appeal or other proceeding at law or in equity, of any person interested in the proceedings: *Provided, however*, That the Commissioners of the District of Columbia may, within fifteen days after the filing of the award of said commissioners, reject the same, in which event new commissioners shall be summoned to appraise the land to be taken,

Rock Creek bridge. Massachusetts avenue extended.

Provisos.
—condemnation proceedings.

Vol. 26, p. 412.

—construction notwithstanding appeal.

—rejection of award.

and the same proceedings shall be had as in the case of the first commission.

Bridge, Connecticut avenue extended.

Toward the construction of a bridge across Rock Creek on the line of Connecticut avenue extended, forty thousand dollars.

Washington Aqueduct.

WASHINGTON AQUEDUCT.

Maintenance, etc.

For operation, maintenance, and repair of the aqueduct and its accessories, including Conduit road, twenty-two thousand dollars.

For protection to the inlet to the conduit at Great Falls, five thousand dollars.

For repairing the by-conduit, Dalecarlia reservoir, ten thousand dollars.

Filtering plant.

For establishing those portions of a filtration plant which are essential to the operation of either system of filtration adopted, including necessary land, grading, masonry, and appurtenances, two hundred thousand dollars, to be available immediately and until expended.

INCREASING THE WATER SUPPLY.

Washington Aqueduct tunnel.

For completing the work on the Washington Aqueduct tunnel and Howard University reservoir, one hundred and thirty-nine thousand and thirty-four dollars and thirty-four cents.

* * * * *

Rock Creek Park.

ROCK CREEK PARK.

Care and improvement.

Alignment of boundaries near Brightwood authorized.

Proviso. —not to diminish park area.

For care and improvement of Rock Creek Park, to be expended under the direction of the board of control of said park, fifteen thousand dollars; and for the purpose of securing better alignment of boundaries the Commissioners of the District of Columbia and the board of control of Rock Creek Park are hereby authorized to adjust and change the boundary between said park and the tract of land near Brightwood, District of Columbia, recently purchased by the District of Columbia for a reservoir site: *Provided*, That the area of Rock Creek Park shall not be diminished by such adjustment or change.

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Approved, June 6, 1900.

June 6, 1900.

CHAP. 790.—An Act Making provision for emergencies in river and harbor works, for certain surveys, and for the diversion of certain appropriations or modification of provisions heretofore made.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

Appropriations for emergencies in river and harbor works, etc. Amount. Expenditure.

That the sum of two hundred and fifty thousand dollars be, and the same is hereby, appropriated, to be paid out of any money in the Treasury not otherwise appropriated, to be immediately available, and to be expended under the direction of the Secretary of War and the supervision of the Chief of Engineers, for the following purposes, to wit:

—for emergencies.

(1) To provide for the restoration of channels, or river and harbor improvements, heretofore established or made by the Government, where, by reason of emergency occur-

ring since the passage of the river and harbor Act of March third, eighteen hundred and ninety-nine, the usual depth of such channels, or customary use of such improvement, can not be maintained, and there is no sufficient fund available for such restoration. The amount herein provided, or so much thereof as is not required for the surveys hereinafter mentioned, shall be allotted by the Secretary of War: *Provided*, That in no case shall such allotment be made unless recommended by the local engineer having such channel or improvement in charge, and the Chief of Engineers, respectively: *Provided further*, That for no single channel or improvement shall a sum greater than ten thousand dollars be allotted; and in expending any such allotment advertisement for bids may be dispensed with on the recommendation of the local engineer.

—allotments.

Provisos.

Recommendation of local engineer, etc., requisite.

Limit for single channel.

(2) For the necessary cost of the surveys herein directed to be made: *Provided*, That the necessary expenses for such examinations and surveys on rivers, or at harbors where work is being carried on by the United States, may be paid from available funds where the unexpended balances of former appropriations for such works are sufficient for such purpose.

Surveys,

—unexpended balances available.

SEC. 2. That the Secretary of War is hereby authorized to cause preliminary examinations and surveys to be made at the localities named in this section, as hereinafter provided. In all cases a preliminary examination shall first be made, which shall embrace information concerning the commercial importance, present and prospective, of the river or harbor mentioned, and a report as to the advisability of its improvement. If upon such preliminary examination the proposed improvement is not deemed advisable, no further action shall be taken thereon without the further direction of Congress; but in case the report shall be to the effect that such river or harbor is worthy of improvement, the Secretary of War is hereby authorized, at his discretion, to authorize surveys to be made and the cost of improving such river or harbor to be estimated and to be reported to Congress, to wit:

Preliminary examinations and surveys directed.

—scope of, etc.

ARKANSAS.

Arkansas.

Red River, in the States of Louisiana, Arkansas, and Texas, and in the Indian Territory, from the city of Shreveport, in the State of Louisiana, to the city of Denison, in the State of Texas: With a view to ascertaining whether the navigation of said river can be permanently improved by a system of cut-offs, levees, locks, and dams, or by any other plan; the cost of said examination and survey, if made, to be paid out of the unexpended balance of the appropriation made for continuing the improvement of said river by the Act of March third, eighteen hundred and ninety-nine.

Vol. 30, p. 1140.

The river and harbor front of the city of Camden, Arkansas, on the Ouachita River: With a view to improving said harbor and grading and protecting the river bank in front of said city, the expenses of said examination and survey to be paid out of any fund now available for the improvement of the Ouachita River.

Alabama.

ALABAMA.

Mobile Harbor: With a view to obtaining channels of a width of three hundred feet at the bottom across the bar below Fort Morgan, with appropriate side slopes, and with mean depths of twenty-five and thirty feet respectively.

Warrior and Tombigbee rivers: With a view to the construction of locks and dams numbered one, two, and three, between the mouth of said rivers and Tuscaloosa; and an amount sufficient for such survey or surveys may, in the discretion of the Secretary of War, be diverted from any appropriation heretofore made for said rivers.

California.

CALIFORNIA.

San Joaquin River, above the mouth of the Stanislaus River: With a view of determining the advisability of closing the mouths of the more important blind sloughs leading from said San Joaquin River and tributaries, especially those known as Finegan, Amphlet, and Walden sloughs, that the water in the main channel of the said San Joaquin River may be retained therein and more effectually promote navigation thereof.

The San Joaquin River and the waterways connecting the same with the Straits of Carquines, extending from the town of Antioch to Suisun Point.

Oakland Harbor: With a view to the improvement of said harbor to meet the needs of present and prospective commerce from the western end of the tidal canal to deep water in San Francisco Bay, including the excavation of a tidal basin.

Connecticut.

CONNECTICUT.

Branford Harbor:

Delaware.

DELAWARE.

Smyrna River: With a view to securing two short crosscuts to shorten the distance from the head of navigation to Delaware Bay.

Mispillion River, from its mouth to the head of navigation.

Florida.

FLORIDA.

Carrabelle Harbor:

Georgia.

GEORGIA.

Savannah Harbor: With a view to a reexamination of the plan for deepening said harbor as submitted in the Report of the Chief of Engineers for eighteen hundred and eighty-eight, page ten hundred and fifty-nine, and a report as to what changes or modifications, if any, are necessary to carry out said plan.

Skiddaway Narrows:

Preliminary examination and survey of the Skiddaway Narrows, connecting the Isle of Hope River with Burnside River, for a channel seventy-five feet wide and six feet deep at mean low water.

ILLINOIS.

Illinois.

Upper Illinois River and Des Plaines River: That the board of three engineers, appointed by the Secretary of War, in pursuance of a paragraph in the river and harbor Act approved March third, eighteen hundred and ninety-nine, to make a survey and estimates of cost of the improvement of the Upper Illinois River and the lower Des Plaines River in Illinois, with a view to the extension of navigation from the Illinois River to Lake Michigan at or near the city of Chicago, is hereby authorized to report the estimates of cost for a channel ten feet deep, and for a channel twelve feet deep, and for a channel fourteen feet deep through said proposed route, and that the said estimates cover and include a proper connection at Lockport with the sanitary and ship canal which has been constructed by the sanitary district of Chicago. The said board of engineers is also further authorized to make a survey and estimate of cost for the improvement of the Lower Illinois River from the end of said proposed route to the mouth of said river, for channels ten, twelve, and fourteen feet deep, respectively, and to report the estimates of cost thereof: *And provided further*, That surveys and estimates of cost shall be made in pursuance of the provisions contained in the Act aforesaid, and especially in accordance with section twenty-two of said Act: *And provided further*, That said surveys shall be commenced and the expenses for said surveys and reports shall be paid as follows: Any unexpended balance of the appropriation of thirty thousand dollars not required for the completion of the survey already contained in said Act shall be first applied and used, and no further expense shall be incurred for such estimates and surveys without the further direction of Congress, and the Secretary of War shall ascertain and report to Congress what amount of money shall be required to complete said surveys and estimates of costs.

Upper Illinois, etc., rivers. Further surveys, etc., by Board of Engineers authorized. Vol. 30, p. 1146.

Provisos. —how made. Vol. 30, p. 1155.

Expenses, etc

Rock River, at the head of the feeder for the Illinois and Mississippi Canal: With a view to the construction of a lock and dam in Rock River in connection with said canal.

The harbor of Harrisonville, in the Mississippi River: With a view of restoring it.

KENTUCKY AND TENNESSEE.

Kentucky and Tennessee.

The east bank of the Mississippi River between the highlands near the city of Hickman, in the State of Kentucky, and Slough Landing, in Lake County, in the State of Tennessee, with a view to constructing such works as may be required to prevent overflows along said section of the river, such examination and survey to be made under the direction of the Mississippi River Commission, the cost thereof to be paid out of the unexpended balance authorized to be expended by said commission.

Maine.

MAINE.

Portland Harbor: With a view to removing so much of Witch Rock as endangers navigation.

Maryland.

MARYLAND.

Harbor of Havre de Grace: With a view to the removal of rocks near the entrance.

Massachusetts.

MASSACHUSETTS.

Boston Harbor: With a view to providing channels two thousand feet wide, or such width as may be necessary, and thirty-five feet deep from the navy-yard at Charlestown and the Chelsea Bridge and Charles River Bridge to President Roads, and from President Roads through Broad Sound Channel to the ocean.

Lynn Harbor: With a view of securing a channel two hundred feet wide and fifteen feet deep at mean low water, including the basin extending beyond the inner ship channel, and the removal of a small point on the eastern bank of the channel near to said basin.

Beverly Harbor: With a view to the straightening, widening, deepening, and otherwise improving the entrance to the harbor and the approaches to the wharves and docks therein.

Michigan.

MICHIGAN.

Muskegon Harbor: With a view to obtaining a channel of the depth of twenty feet and a uniform width of three hundred feet from the exterior to the interior lake; the plan to provide for sheet piling to prevent erosion along the banks not protected by cribs.

Saint Clair Flats Canal, in Lake Saint Clair: With a view to doubling the capacity of the so-called Saint Clair Flats Canal.

Detroit River: With a view to obtaining a sufficient depth of water in the channel on the west side of Grosse Isle.

Minnesota.

MINNESOTA.

Burlington Bay, Lake County: With a view to improving said bay and the construction of a harbor therein.

Warroad Harbor and Warroad River.

Montana.

MONTANA.

Kootenai River between Jennings, Montana, and the international boundary line, with a view to removing obstructions to navigation.

New Hampshire.

NEW HAMPSHIRE.

Hendersons Point, Portsmouth Harbor: With a view of removing a portion of said point for the purpose of improving navigation to the navy-yard.

NEW JERSEY.

New Jersey.

Beach Thoroughfare:

NEW YORK.

New York.

Lake Erie entrance to Black Rock Harbor and Erie Basin.

Grasse River from its confluence with the Saint Lawrence River to Massena: With a view to obtaining a depth of twenty-one feet.

Saint Lawrence River, at the head of Long Sault Island: With a view of removing the rock obstruction in the south branch of said river, so as to give a navigable depth of twenty feet of water.

Buttermilk Channel, New York Harbor: With a view to obtaining a channel of the same width and depth as those contemplated by the project adopted for Bay Ridge and Red Hook channels.

Fire Island Inlet, in Great South Bay, to Patchogue River: With a view to obtaining a channel not less than ten feet in depth and two hundred feet in width at mean low water.

NEVADA.

Nevada.

Colorado River: Between El Dorado Canyon and Rioville, Nevada, with a view to the extension of navigation to Rioville.

NORTH CAROLINA.

North Carolina.

Trent River from the junction of Trent River with Neuse River up to Trenton: With a view to obtaining a depth of eight feet at mean low water at the city of Newbern and up to the wharves and freight depots of said city, and a channel fifty feet wide and eight feet deep from Newbern through Foy's Flats to Polloksville, and a channel thirty feet wide and four feet deep at mean low water from Polloksville to Trenton.

Wilmington Harbor: With a view to providing a sufficient width and depth to permit vessels now using said harbor to turn or swing around therein, Cape Fear River, with a view to obtaining a navigable channel from Wilmington to Fayetteville of four, six, or eight feet at mean low water.

Pasquotank River: With the view of obtaining a navigable depth of sixteen feet at mean low water from South Mills, on the Pasquotank River, thence down the Pasquotank River, through Albemarle Sound, Croatan Sound, Pamlico Sound, and Core Sound, to Beaufort Inlet, including also cost of procuring a navigable depth of eighteen feet through Beaufort Inlet and eighteen feet through Ocracoke Inlet, respectively.

Scuppernong River: With the view of improving the bar at the mouth of Scuppernong River, emptying into Albemarle Sound, North Carolina, to the end that the channel be dredged one thousand two hundred feet long,

one hundred and fifty feet wide, with nine feet depth of water at mean low tide.

Ohio.

OHIO.

Cleveland Harbor: With a view to the further improvement of said harbor: First, by such additional construction or extension as may be necessary to provide a safer and better entrance for vessels at the main entrance to the breakwater in said harbor. Second, to provide such additional harbor room as may be found necessary by an extension eastward of the breakwater now under construction in said harbor.

Sandusky Harbor: With a view to obtaining and maintaining a channel twenty-one feet deep at mean lake level, with a width of four hundred feet in the approaches to harbor front and three hundred feet in the harbor channels.

Ohio River, Kentucky.

OHIO RIVER (IN KENTUCKY).

With a view to the construction of a pier for a harbor of refuge on the south shore at or near the city of Maysville, Kentucky.

With a view to ascertaining the desirability of acquiring the island immediately below the Louisville and Portland Canal in the Ohio River, known as Sand Island, and probable cost of purchasing the same.

Ohio River.

OHIO RIVER.

Continuing and completing the survey of the Ohio River from Marietta to the mouth of the Big Miami River in accordance with the provisions of the river and harbor Act of March third, eighteen hundred and ninety-nine, the expense thereof to be paid out of any moneys already appropriated and not expended for the general improvement of the Ohio River.

Oregon.

OREGON.

Columbia River between the foot of The Dalles Rapids and the head of Celilo Falls, Oregon and Washington; with a view to the construction of a canal and locks to overcome the obstructions to navigation.

Rhode Island.

RHODE ISLAND.

Ohio Reef, located in the east passage of Narragansett Bay: With a view to determining the advisability of removing said reef as a dangerous obstruction to the navigation of said bay.

Sakonnet Harbor: To ascertain the advisability and cost of removing rocks which are an obstruction to navigation.

Pawtucket River: With a view to securing a channel two hundred feet wide and eighteen feet deep from the mouth of the river at Providence to the lower wharves in the city of Pawtucket.

SOUTH CAROLINA.

South Carolina.

Great Pedee River between Cheraw and the Wilmington, Columbia and Augusta Railroad bridge.

Ashley River from the city of Charleston to the head of navigation.

SOUTH DAKOTA.

South Dakota.

For a survey of the Sioux River and an estimate of the cost of constructing a dam for the storage of the water of said stream in Lake Kempeska and Lake Ponsett, together with an estimate of the capacity of said reservoir and the feasibility of utilizing the same.

TEXAS.

Texas.

Trinity River from the city of Dallas to the city of Fort Worth: With a view to securing a navigable depth of four, five, and six feet respectively.

Galveston Bay: With a view to widening, deepening, and extending the present channel from a point where it now is of sufficient width and depth to a point opposite Twentieth street; thence to a point opposite Thirty-fifth street; thence to a point opposite Fifty-first street, with a report as to the relative importance of the respective sections.

Also for survey and making plans for improvement of inner harbor of Galveston.

Sabine Pass: With a view to widening and straightening the main ship channel and increasing the depth, if necessary, from a point one thousand feet north of the United States life-saving station to Sabine Lake.

Brazos River from its mouth to the city of Waco: With a view to procuring a navigable depth of four, five, and six feet, first, from its mouth to the town of old Washington, in Washington County; second, from said town of old Washington to the city of Waco. In case a survey is made, the report thereon shall show the most advantageous depth to each point, and whether a system of locks and dams will be necessary, and if so, the cost and location of same.

VIRGINIA.

Virginia.

Quantico Creek:

Norfolk: To remove bar and secure depth of twenty-eight feet at point between the twenty-eight foot channel and the pier of the Southern Railway Company near Norfolk, Virginia.

Appomattox River: Resurvey and estimate for the deflection of the river at Petersburg.

Pagan River from Smithfield, Virginia, to James River, with a view to securing a channel eighty feet wide and ten feet deep at mean low tide, or such improvement as may be found expedient.

Chesconnessex Creek, an estuary of the Chesapeake Bay, running up into land on the western side of Accomac County, Virginia, with a view to dredging the same.

Washington.

WASHINGTON.

Tacoma Harbor:

Snake River, in the States of Idaho and Washington, from the head of navigation on said river to the point of junction with the Columbia River, with a view to improving said river.

Wisconsin.

WISCONSIN.

Manitowoc Harbor: With a view of making a harbor of refuge with a depth of not less than twenty feet.

Sturgeon Bay and Lake Michigan Ship Canal: With a view to deepening the Sturgeon Bay and Lake Michigan Ship Canal to eighteen feet; said improvement to begin at the Lake Michigan end of said waterway and to continue throughout the length of said canal and in the waters of Sturgeon Bay so far as is necessary to secure a navigable channel having a depth of eighteen feet of water from Lake Michigan to the waters of Green Bay.

Milwaukee Harbor.

Proviso. —preliminary examinations only.

Milwaukee Harbor: With a view to necessary enlargement and suitable protection therefor: *Provided, however,* That at the following named localities preliminary examinations only shall be made: Mahon Harbor, Delaware; Long Prairie River, and its sources; Sioux River, South Dakota.

Channel, South Pass, Mississippi River.

Termination of Eads contract authorized.

Vol. 18, p. 465.

Vol. 20, p. 168.

Vol. 20, p. 376.

SEC. 3. That the Secretary of War is hereby authorized, in his discretion, to terminate the contract heretofore entered into with the late James B. Eads for the maintenance of the channel through the South Pass of the Mississippi River, in pursuance of an Act of Congress approved March third, eighteen hundred and seventy-five, entitled "An Act authorizing James B. Eads and others to construct jetties, and so forth, and to maintain channels between South Pass of Mississippi River and Gulf of Mexico," and of an Act of Congress approved June nineteenth, eighteen hundred and seventy-eight, entitled "An Act to amend an Act entitled 'An Act making appropriations for the repair, preservation, and completion of certain public works on rivers and harbors, and for other purposes,'" approved March third, eighteen hundred and seventy-five, and of an Act of Congress approved March third, eighteen hundred and seventy-nine, entitled "An Act to amend an Act entitled 'An Act making appropriations for the repair, preservation, and completion of certain public works on rivers and harbors, and for other purposes,'" approved March third, eighteen hundred and seventy-five.

Purchase of dredges, etc., authorized.

The Secretary of War is also authorized, in his discretion, to purchase from the heirs or legal representatives of the said James B. Eads the dredges and other plant, including real estate, now used by them for the maintenance of said channel, or such portion of said plant as he may deem desirable; and in case the Secretary of War and the heirs or legal representatives of the estate of James B. Eads, deceased, are unable to agree upon the price to be paid for said dredges and plant, including real estate, or so much thereof as the Secretary of War may deem necessary to purchase, then such price

shall be assessed by a board of three appraisers to be appointed as follows: One appraiser to be appointed by the Secretary of War, one by the heirs or legal representatives of James B. Eads, deceased, and in case these two fail to agree, they shall jointly choose a third appraiser, and the three so appointed shall, by a majority vote, duly appraise the price to be paid for said dredges and plant, including real estate, and in case such appraisal is approved by the Secretary of War, the same shall be deemed to be the price which the Secretary of War is authorized to pay for said dredges and plant, including real estate, or so much thereof as the Secretary of War may deem necessary to purchase: *Providing*, That in no event shall more than two hundred thousand dollars be paid for all the dredges, plant, and real estate owned or possessed by the heirs or legal representatives of James B. Eads, deceased, at or about the South Pass. And in case the Secretary of War shall terminate said contract the sum of two hundred thousand dollars, or so much thereof as may be necessary, is hereby appropriated, out of any money in the Treasury not otherwise appropriated, to be immediately available, for the purchase of the whole or a part of said plant, or for otherwise providing a proper plant for the maintenance of said Pass. In case of the termination of said contract, by virtue of the provisions hereof or by expiration of said contract, the Secretary of War is hereby directed to take charge of said channel, including the jetties, and all auxiliary works connected therewith, and thereafter to maintain with the utmost efficiency said South Pass Channel; and for that purpose he is hereby authorized to draw his warrants from time to time on the Treasurer of the United States, until otherwise provided for by law, for such sums of money as may be necessary, not to exceed in the aggregate for any one year one hundred thousand dollars. In the event that the Secretary of War shall elect to terminate said contract, any sum which shall at that time have been appropriated by Congress to pay what would be due to the heirs or legal representatives of said James B. Eads at the expiration of said contract may be used by him in making such payment, when he shall terminate the same, anything in the law making such appropriation to the contrary notwithstanding.

—board to assess price.

Proviso.
—limit of payment.

—appropriation.

Secretary of War to maintain channel if contract is terminated.

—appropriation.

Payment of available funds to Eads heirs authorized.

SEC. 4. That the Secretary of War is authorized in his discretion to direct diversions from appropriations heretofore made or to make modifications in projects heretofore included in river and harbor bills as follows:

Diversion of appropriations authorized.

Cumberland Sound: The sum of fifty thousand dollars, or so much thereof as may be necessary, may be diverted from the sums of money heretofore appropriated and now standing to the credit of the existing project for jetty work in Cumberland Sound, in the States of Florida and Georgia, to be used for sluicing and dredging at the mouth of said sound or elsewhere in said sound, and belonging to said project, where sluicing and dredging may be needed or required; but nothing herein contained shall be construed to increase the limit of cost of said project

Cumberland Sound.

Vol. 30, p. 1106, etc.

or improvement beyond the amount fixed by the Acts making appropriation for said project and fixing the ultimate sum which may finally be devoted to said project: *And provided further*, That any changes in the location of the jetties which the Secretary of War may consider for the interest of the work are authorized.

Proviso. Change of jetties.

Lake George Channel, Mich., etc.

Lake George Channel and connecting waters below Sault Sainte Marie, Michigan: So as to restore and make available a channel formerly used through said lake of a depth and a width not less than formerly employed, an amount not exceeding one hundred thousand dollars may be diverted from the balance remaining from the amounts heretofore appropriated for the Saint Marys River at the Falls in Michigan.

Buffalo Harbor, N. Y.

Buffalo Harbor, New York: The sum of ten thousand dollars, or so much thereof as may be necessary, may be diverted from amounts now available for maintenance of Buffalo Harbor, in deepening the entrance to Buffalo Harbor and the City Ship Canal.

Milford Haven, Va.

Milford Haven, Virginia: The unexpended balance of the appropriation for the improvement of the harbor at Milford Haven, Virginia, or any part thereof, may, in the discretion of the Secretary of War, be used for the improvement of the bar within said harbor.

Charleston, S. C.

Charleston Harbor, South Carolina: The amounts heretofore authorized for a contract or contracts for materials and work, or so much thereof as may be necessary, may be expended in the work of dredging in accordance with the approved project.

Winyah Bay, S. C.

Winyah Bay, South Carolina: The dredge or dredges employed in connection with the work of improvement at the entrance to Winyah Bay, and such other dredges owned or controlled by the Government as are used on Winyah Bay River systems and canals, may be used in dredging the shoal places between the entrance and the city of Georgetown, South Carolina, the places at which and depths to which such dredging shall be done to be determined by the Secretary of War, upon the recommendation of the Chief of Engineers, United States Army; and any expense so caused shall be paid from amounts heretofore appropriated for said Winyah Bay.

California. Purchase of sites for débris dams, etc. Vol. 29, p. 232.

Land for débris dams and impounding works in California: From the funds appropriated by the river and harbor Act of eighteen hundred and ninety-six for the construction of débris dams and impounding works in California, the sum of ten thousand dollars may be expended for the purchase of lands necessary for the construction of said works: *Provided*, That an equal amount is paid by the State of California: *And provided further*, That the Secretary of War may proceed at once with the construction of said works, and that the gross expenditure for lands in the construction of said works shall not exceed in the aggregate twenty thousand dollars: *And provided further*, That where in such works more than one dam or impounding work is embraced within a project

Provisos. State to pay half. Limit of cost. Construction in sections, etc.

the Secretary of War may proceed to construct the said works in parts or sections and submit the plans and specifications for such parts or sections to the State board of examiners of said State for approval under the laws thereof: *And provided further*, That in all cases one-half of the expense of such works shall be paid by the State of California.

State to pay half.

Lorain Harbor, Ohio: The Secretary of War may enter into a contract or contracts for portions of the work authorized by the Act of March third, eighteen hundred and ninety-nine, without regard to the estimate heretofore made in the report of the Chief of Engineers for the completion of said work: *Provided*, That the total amount contracted for shall not exceed the sum heretofore authorized: *Provided*, That the cost of any portion of such work shall not exceed by more than one-tenth the estimate of cost as heretofore made in the Report of Chief of Engineers.

Lorain Harbor, Ohio.
Vol. 30, p. 1129.
Provisos.
Limit of cost

Upper White River, Arkansas, Lock and Dam Numbered Two: That the provision in the river and harbor Act approved March third, eighteen hundred and ninety-nine, making appropriation for improving Upper White River, Arkansas, is hereby amended to read as follows:

Upper White River, Ark.

"Improving Upper White River, Arkansas: For the construction of Lock and Dam Numbered One, on Upper White River, at or near Batesville, according to the project, plans, and specifications submitted in report printed in House Document Numbered Seventy-eight, Fifty-fourth Congress, second session, to complete said lock and dam, one hundred and sixty thousand dollars; and the Secretary of War may also expend toward the construction of Lock and Dam Numbered Two, according to the same plan, by contract or in any manner that in his judgment may be most economical and advantageous to the Government, a sum not to exceed one hundred and fifty thousand dollars, to be paid for as appropriations may from time to time be made by law."

Vol. 30, p. 1142, amended.

Ocmulgee River, Georgia: The provision in the river and harbor Act approved March third, eighteen hundred and ninety-nine, authorizing contracts to be made for improving Ocmulgee River, is hereby amended to read as follows: "*Provided*, That a contract or contracts may be entered into by the Secretary of War to complete the present project of improvement, or the required materials may be purchased and the work of improvement be carried on otherwise than by contract, to be paid for as appropriations may from time to time be made by law, not to exceed in the aggregate one hundred and thirty-six thousand dollars, exclusive of amounts herein and heretofore appropriated."

Ocmulgee River, Ga.
Vol. 30, p. 1138, amended.
Proviso.
Contracts

Yaquina Bay, Oregon: The balance remaining of twenty-five thousand dollars appropriated by the river and harbor Act of eighteen hundred and ninety-six for said Yaquina Bay, or so much thereof as may be necessary, may be expended in removing the cluster of rocks on one side of the channel, located about two thousand feet beyond

Yaquina Bay, Oreg.
Vol. 29, p. 214.

the end of the south jetty, in accordance with the recommendation of a board of engineers made November fourteenth, eighteen hundred and ninety-nine, in House Document Numbered One hundred and ten, Fifty-sixth Congress, first session.

Ashland Harbor, Wis. Vol. 30, p. 1132.

Ashland Harbor, Wisconsin: That in lieu of completing the shore end of the breakwater at Ashland, Wisconsin, as provided for in the river and harbor Act of March third, eighteen hundred and ninety-nine, there shall be substituted a breakwater, starting at a point on the shore about two thousand six hundred feet east of the point at which the existing shore arm of breakwater would meet shore if prolonged, and running in a direction parallel to existing breakwater for a distance of four thousand seven hundred feet, or of such a length as may be necessary to fully protect the harbor of Ashland.

Warroad River, Minn. Vol. 30, p. 1145, amended.

Warroad River, Minnesota: The following paragraph in an Act entitled "An Act making appropriations for the construction, repair, and preservation of certain public works on rivers and harbors, and for other purposes," approved March third, eighteen hundred and ninety-nine, to wit:

"For removing a sand bar at the mouth of Warroad River, Minnesota, three thousand dollars, or so much thereof as may be necessary," is hereby amended so as to read as follows:

"For improving the mouth of Warroad River, Minnesota, three thousand dollars, or so much thereof as may be necessary."

Mississippi River. Vol. 30, p. 1127, amended.

Outlet of Mississippi River: Section one of the Act entitled "An Act making appropriations for the construction, repair, and preservation of certain public works on rivers and harbors, and for other purposes," approved March third, eighteen hundred and ninety-nine, be, and the same is hereby, amended as follows: In the paragraph beginning "Improving outlet of the Mississippi River," strike out the word "two" before the word "dredges" and insert in lieu thereof the words "one or more."

East Channel, New York Harbor, renamed Ambrose Channel. Vol. 30, p. 1123. *Post*, p. 5528.

SEC. 5. That the so-called East Channel across Sandy Hook Bar, New York Harbor, for the improvement of which provision was made by the river and harbor Act approved March third, eighteen hundred and ninety-nine, shall hereafter be known as Ambrose Channel.

Guam. Harbor improvement board authorized.

SEC. 6. That the Secretary of the Navy is hereby authorized and directed to appoint two naval officers, and the Secretary of War one engineer officer, to constitute a board whose duty it shall be, under the direction of the Secretary of the Navy, to make a survey, plan, and estimates for the improvement of a harbor at the island of Guam; and the sum of ten thousand dollars, or so much thereof as may be necessary, is hereby appropriated, out of any money in the Treasury not otherwise appropriated, for this purpose.

Approved, June 6, 1900.

CHAP. 791.—An Act Making appropriations for sundry civil expenses of the Government for the fiscal year ending June thirtieth, nineteen hundred and one, and for other purposes.

June 6, 1900.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums be, and the same are hereby, appropriated, for the objects hereinafter expressed, for the fiscal year ending June thirtieth, nineteen hundred and one, namely:

Appropriations for sundry civil expenses.

* * * * *

UNDER THE WAR DEPARTMENT.

War Department.

* * * * *

BUILDINGS AND GROUNDS IN AND AROUND WASHINGTON.

Washington, D. C.

For the improvement and care of public grounds, as follows:

Buildings and Grounds.

For improvement and maintenance of grounds south of Executive Mansion, four thousand dollars.

Improvement and care.

For ordinary care of greenhouses and nursery, two thousand dollars.

For ordinary care of Lafayette Park, one thousand dollars.

For ordinary care of Franklin Park, one thousand dollars.

For improvement and ordinary care of Lincoln Park, two thousand dollars.

For care and improvement of Monument Grounds, five thousand dollars.

For continuing improvement of reservation numbered seventeen, and site of old canal northwest of same, three thousand dollars: *Provided*, That no part thereof shall be expended upon other than property belonging to the United States.

Reservation No. 17.

Proviso.

Expenditure.

For construction and repair of post-and-chain fences, repair of high iron fences, constructing stone coping about reservations, painting watchmen's lodges, iron fences, vases, lamps, and lamp-posts; manure, and hauling the same, and removing snow and ice; purchase and repair of seats and tools; trees, tree and plant stakes, labels, lime, whitewashing, and stock for nursery, flower pots, twine, baskets, wire, splints, moss, and lycopodium, to be purchased by contract or otherwise, as the Secretary of War may determine; care, construction, and repair of fountain; abating nuisances, cleaning statues, and repairing pedestals, fifteen thousand eight hundred and fifty dollars.

For improvement, care, and maintenance of various reservations, twenty thousand dollars.

For improvement, maintenance, and care of Smithsonian grounds, two thousand five hundred dollars.

For improvement, care, and maintenance of Judiciary Park, two thousand five hundred dollars.

For laying asphalt walks in various reservations, two thousand dollars.

Half appropriations from District revenues.

One-half of the foregoing sums under "Buildings and grounds in and around Washington" shall be paid from the revenues of the District of Columbia and the other half from the Treasury of the United States.

Grounds, Executive Departments.

For improvement, care, and maintenance of grounds of Executive Departments, one thousand dollars.

Limit for concrete, etc., pavements.

That under appropriations herein contained no contract shall be made for making or repairing concrete or asphalt pavements in Washington City at a higher price than one dollar and eighty cents per square yard for a quality equal to the best laid in the District of Columbia prior to July first, eighteen hundred and eighty-six, and with a base of not less than six inches in thickness.

Executive Mansion.

For improvement and maintenance of Executive Mansion grounds (within iron fence), one thousand dollars.

For construction of an iron and brick storehouse at the nursery, and for each and every purpose connected therewith, six thousand five hundred dollars, to be immediately available.

EXECUTIVE MANSION: For care, repair, and refurnishing of Executive Mansion, twenty thousand dollars, to be expended by contract or otherwise, as the President may determine.

—plans for extending.

For continuing plans for extending the Executive Mansion, prepared in the office of the engineer officer in charge of public buildings and grounds, for completion of drawings, model and specifications, and for each and every purpose connected therewith, six thousand dollars, or so much thereof as may be necessary; the Chief of Engineers of the United States Army shall have the employment of all persons connected with this work.

Plans for park improvements.

The Chief of Engineers of the United States Army is authorized to make an examination and to report to Congress on the first Monday in December, nineteen hundred, plans for the treatment of that section of the District of Columbia situated south of Pennsylvania avenue and north of B street southwest, and for a suitable connection between the Potomac and the Zoological parks, and in making such examinations and plans he is authorized to employ a landscape architect of conspicuous ability in his profession; for services and expenses incident to said examination and report the sum of four thousand dollars is hereby appropriated.

Fuel, etc.

For fuel for the Executive Mansion, greenhouses, and stable, three thousand dollars.

For care and necessary repair of greenhouses, five thousand dollars.

For repairs to conservatory, Executive Mansion, two thousand dollars.

Lighting.

LIGHTING THE EXECUTIVE MANSION AND PUBLIC GROUNDS: For gas, pay of lamplighters, gas fitters, and laborers; purchase, erection, and repair of lamps and lamp-posts; purchase of matches, and repairs of all kinds; stoves, fuel, and lights for office and office stable, watch-

men's lodges, and for the greenhouses at the nursery, twelve thousand five hundred dollars: *Provided*, That for each five-foot burner not connected with a meter in the lamps on the public grounds not more than twenty dollars shall be paid per lamp for gas, including lighting, cleaning, and keeping the lamps in repair, under any expenditure provided for in this Act; and said lamps shall burn every night, on the average, from fifteen minutes after sunset to forty-five minutes before sunrise; and authority is hereby given to substitute other illuminating material for the same or less price, and to use so much of the sum hereby appropriated as may be necessary for that purpose: *Provided further*, That three thousand four hundred dollars of the foregoing sum shall be paid from the revenues of the District of Columbia and the remainder from the Treasury of the United States.

Provisos. —Maximum per lamp. —to burn every night, etc. —amount payable from District revenues.

For lighting six arc electric lights in Executive Mansion grounds within the iron fence three hundred and sixty-five nights, at not exceeding seventy-two dollars per light per annum, which shall cover the entire cost to the United States of lighting and maintaining in good order each electric light in said grounds, four hundred and thirty-two dollars.

Electric lights.

For lighting arc electric lights in public grounds as follows: For seven in grounds south of the Executive Mansion, thirty-two in Lafayette, Franklin, Judiciary, and Lincoln parks, and fourteen in grounds south of Executive Mansion and in Monument Park, at not exceeding seventy-two dollars per light per annum, which sums shall cover the entire cost of lighting and maintaining in good order each of said arc electric lights; in all, three thousand eight hundred and sixteen dollars, one-half of which sum shall be paid from the revenues of the District of Columbia and the other half from the Treasury of the United States.

—in parks.

REPAIR OF WATER PIPES: For repairing and extending water pipes, purchase of apparatus for cleaning them, purchase of hose, and for cleaning the springs and repairing and renewing the pipes of the same that supply the Capitol, the Executive Mansion, and the building for the State, War, and Navy Departments, two thousand five hundred dollars.

Repair of water pipes.

TELEGRAPH TO CONNECT THE CAPITOL WITH THE DEPARTMENTS AND GOVERNMENT PRINTING OFFICE: For care and repair of existing lines, one thousand five hundred dollars.

Telegraph, Capitol, Departments, etc.

WASHINGTON MONUMENT: For the care and maintenance of the Washington Monument, namely: For one custodian, at one hundred dollars per month; one steam engineer, at eighty dollars per month; one assistant steam engineer, at sixty dollars per month; one fireman, at fifty dollars per month; one assistant fireman, at forty-five dollars per month; one conductor of elevator car, at seventy-five dollars per month; one attendant on floor, at sixty dollars per month; one attendant on top floor, at sixty dollars per month; three night and day watchmen, at

Washington Monument. Maintenance.

sixty dollars per month each; in all, eight thousand five hundred and twenty dollars.

Fuel, etc.

For fuel, lights, oil, waste, packing, tools, matches, paints, brushes, brooms, lanterns, rope, nails, screws, lead, electric lights, heating apparatus, oil stoves for elevator car and upper and lower floors, repairs to engines, boilers, dynamos, elevator, and repairs of all kinds connected with the Monument and machinery, and purchase of all necessary articles for keeping the Monument, machinery, elevator, and electric-light plant in good order, three thousand dollars.

Installation of electric power for the service of the Monument: For addition to boiler house, six thousand five hundred dollars, to be immediately available.

For one dynamo and connections, including installation of new system, twenty thousand dollars, to be immediately available.

* * * * *

Yellowstone National Park.

IMPROVEMENT OF THE YELLOWSTONE NATIONAL PARK: For the repair and maintenance of existing roads and bridges and improvement and protection of the Yellowstone National Park, to be expended by and under the direction of the Secretary of War, sixty thousand dollars, of which amount five thousand dollars shall be immediately available for the repair of roads: *Provided*, That of this amount twenty thousand dollars, or so much thereof as may be necessary, shall be used in the construction of a wagon road and the necessary bridges through the Yellowstone Park Timber Reserve along the North Fork of the Stinking-water or Shoshone River and through the Yellowstone Park by way of the Jones Creek trail or other most practicable route to a point on the Yellowstone River near where said river flows from Yellowstone Lake: *Provided further*, That road extensions and improvements shall hereafter be made in said park under and in harmony with a general plan of roads and improvements to be approved by the Chief of Engineers of the Army.

Provisos.
Wagon road authorized.

Road extensions.

* * * * *

Engineer Department.

ENGINEER DEPARTMENT.

South Pass, Mississippi River.
—payment to heirs of James B. Eads authorized.

Vol. 18, p. 465.

FOR CONSTRUCTING JETTIES AND OTHER WORKS AT SOUTH PASS, MISSISSIPPI RIVER: To enable the Secretary of War to pay to the legal representatives of James B. Eads, deceased, the second moiety of the sum of one million dollars retained by the United States under the Act of March third, eighteen hundred and seventy-five (first section on page four hundred and sixty-five of Eighteenth Statutes), to be paid, all or in part, on the expiration of twenty years' maintenance of the channel, five hundred thousand dollars.

—use of dredges in unusual obstructions.

The Secretary of War is hereby authorized and empowered, in his discretion, in case any unusual obstruction to navigation in the channel of South Pass, Mississippi River, should occur during the fiscal year nineteen hundred and one, to use any dredges or tugboats of the Mis-

sissippi River Commission for the purpose of removing the same. And the sum of twenty-five thousand dollars, or so much thereof as may be necessary, is hereby appropriated, to be expended in the discretion of the Secretary of War in improving or altering such dredge or dredges so as to make the same available for use in said South Pass.

Toward the construction of works on harbors and rivers, under contract or otherwise, and within the limits authorized by law, namely: Rivers and harbors, improvements.

Improving harbor at Charleston, South Carolina, under river and harbor Act of eighteen hundred and ninety-two: For dredging, forty-five thousand dollars. Charleston, S. C. Vol. 27, p. 91.

For works authorized by the river and harbor Act of eighteen hundred and ninety-six, as follows: Vol. 29, p. 222, etc.

Improving Bayou Plaquemine, Louisiana: For continuing improvement, two hundred thousand dollars. Bayou Plaquemine, La.

Improving harbor at Cleveland, Ohio: For continuing improvement, one hundred and seventy-five thousand dollars. Cleveland, Ohio.

Improving Chicago River, Illinois: For continuing improvement from its mouth to the stock yards on the South Branch, and to Belmont avenue on the North Branch, sixty-two thousand dollars. Chicago River, Ill.

Harbor of refuge, Delaware Bay, Delaware: For continuing construction, four hundred and fifty thousand dollars. Delaware Bay, Del.

Improving harbor at Duluth, Minnesota, and Superior, Wisconsin: For continuing improvement, seven hundred and ninety-three thousand one hundred and eighty-seven dollars and fifty cents. Duluth, Minn. Superior, Wis.

Improving Grays Harbor, Washington: For continuing improvement of harbor and bar entrance, fifty thousand dollars. Grays Harbor, Wash.

Illinois and Mississippi Canal: For continuing construction, one million dollars. Illinois and Mississippi Canal.

Improving Kentucky River, Kentucky: For continuing improvement, seventy-five thousand dollars. Kentucky River, Ky.

Improving waterway from Keweenaw Bay to Lake Superior, Michigan: For continuing improvement of water communication across Keweenaw Point, one hundred and ten thousand dollars. Waterway from Keweenaw Bay to Lake Superior, Mich.

Improving harbor at Oakland, California: For continuing improvement, one hundred and eighty thousand dollars. Oakland, Cal.

Improving Ohio River below Pittsburg, Pennsylvania: For continuing construction of Dams Numbered Two, Three, Four, and Five, between Davis Island Dam and Dam Numbered Six, five hundred and ninety-five thousand dollars. Ohio River. Dams 2, 3, 4, 5, and 6.

Improving Providence River and Narragansett Bay, Rhode Island: For continuing improvement, fifty-four thousand four hundred and eighty-nine dollars. Providence River and Narragansett Bay, R. I.

Improving Sabine Pass, Texas: For completing improvement of harbor at Sabine Pass, thirty-six thousand dollars. Sabine Pass, Tex.

Improving Winyaw Bay, South Carolina: For continuing improvement of harbor at Winyaw Bay, two hundred and eighty-five thousand dollars. Winyaw Bay, S. C.

Vol. 30, p. 1128, etc.

For works authorized by the river and harbor act of eighteen hundred and ninety-nine, as follows:

Ashtabula, Ohio.

Improving harbor at Ashtabula, Ohio: For continuing improvement, one hundred and ten thousand dollars.

Boston, Mass.

Improving harbor at Boston, Massachusetts: For completing improvement under project for thirty-foot depth through Broad Sound Channel, three hundred and seventeen thousand dollars.

Buffalo entrance to Erie Basin, etc.

Improving Buffalo Entrance to Erie Basin and Black Rock Harbor, New York: For completing improvement, one hundred and ninety-one thousand seven hundred and one dollars and twenty-five cents.

Bridgeport, Conn.

Improving harbor at Bridgeport, Connecticut: For continuing improvement, fifty thousand dollars.

Gowanus Bay, N. Y.

Improving channel in Gowanus Bay, New York: For continuing improvement of Bay Ridge and Red Hook channels, two hundred and sixty-two thousand dollars:

Proviso. East Channel, etc., renamed Ambrose Channel. Vol. 30, p. 1123. *Ante*, p. 5522.

Provided, That the so-called East Channel across Sandy Hook Bar, New York Harbor, for the improvement of which provision was made by the river and harbor Act approved March third, eighteen hundred and ninety-nine, shall hereafter be known as Ambrose Channel.

Black River, Ohio.

Improving harbor at Black River, Ohio: For continuing improvement, one hundred and twenty-five thousand dollars.

Black Warrior River, Ala.

Improving Black Warrior River, Alabama: For completing construction of Lock and Dam Numbered Four, above Tuscaloosa, eighty-six thousand eight hundred and twenty-four dollars.

Big Sandy River, W. Va. and Ky.

Improving Big Sandy River, West Virginia and Kentucky: For continuing improvement by the construction of two locks and dams between Louisa and mouth of the river, two hundred and eighty thousand dollars.

Charleston, S. C.

Improving harbor at Charleston, South Carolina: For completing improvement, one hundred and seventy-five thousand dollars.

Cape Porpoise, Me.

Improving harbor at Cape Porpoise, Maine: For completing improvement, ten thousand dollars.

Calumet, Ill.

Improving harbor at Calumet, Illinois: For continuing improvement, one hundred and eighty-five thousand three hundred and fifty dollars.

Congaree River, S. C.

Improving Congaree River, South Carolina: For continuing improvement from Gervais street bridge, Columbia, to Granby, one hundred thousand dollars.

Delaware River, Pa. and N. J.

Improving Delaware River, Pennsylvania and New Jersey: For continuing improvement, two hundred and seventy thousand five hundred dollars.

Detroit River, Mich.

Improving Detroit River, Michigan: For continuing improvement, two hundred thousand dollars.

Everett, Wash.

Improving harbor at Everett, Washington: For continuing improvement, one hundred and thirty-five thousand dollars.

Hudson River, N. Y.

Improving Hudson River, New York: For continuing improvement, four hundred thousand dollars.

Hay Lake Channel, St. Marys River, Mich.

Improving Hay Lake Channel, Saint Marys River, Michigan: For continuing improvement, two hundred and fifty thousand dollars.

Improving harbor at Kenosha, Wisconsin: For completing improvement, one hundred and thirty-five thousand dollars. Kenosha, Wis.

Improving harbor at Mobile, Alabama: For continuing improvement, five hundred thousand dollars. Mobile, Ala.

Improving Mississippi River from the mouth of the Ohio to Minneapolis, Minnesota: For continuing improvement between Saint Paul and Minneapolis, one hundred and eighty-five thousand dollars: *Provided*, That of said amount the sum of one hundred dollars may be used to reimburse Loren Fletcher for a like sum advanced by him to expedite the transfer to the United States of title to land needed in connection with the construction of Lock and Dam Numbered Two. Mississippi River, mouth of Ohio to Minneapolis. *Proviso.* Loren Fletcher, payment to.

Improving Passes of the Mississippi River: For completing improvement by constructing sill across Pass a Loutre and by constructing and operating one or more dredges, three hundred thousand dollars. Improving Passes.

Harbor of refuge at Milwaukee Bay, Wisconsin: For completing improvement, one hundred and five thousand six hundred and fifty dollars. Milwaukee, Wis.

Improving Monongahela River: For completing improvement at Locks Numbered Three and Six and by construction of floating plant as authorized by the river and harbor Act approved March third, eighteen hundred and ninety-nine, one hundred and thirty-five thousand five hundred and fifty-six dollars. Monongahela River. Vol. 30, p. 1133.

Improving harbor at Michigan City, Indiana: For completing improvement of outer harbor, one hundred and ninety-five thousand dollars. Michigan City, Ind.

Improving harbor at New Haven, Connecticut: For continuing improvement, fifty thousand dollars. New Haven, Conn.

Improving waterway from Norfolk, Virginia, to sounds of North Carolina: For continuing improvement of Deep Creek, Virginia, Turners Cut, Croatan Sound, and Pasquotank River, North Carolina, two hundred thousand dollars. Norfolk, Va., waterway.

Improving Ohio River below Pittsburg, Pennsylvania: For continuing construction of Dams Numbered Thirteen and Eighteen, four hundred and seventy thousand dollars. Ohio River. Dams 13 and 18.

Improving Osage River, Missouri: For completing construction of lock and dam, one hundred and forty-six thousand dollars. Osage River Mo.

Improving Ocmulgee River, Georgia: For continuing improvement, forty thousand dollars. Ocmulgee River, Ga.

Harbor of refuge at Portage Lake, Michigan: For completing improvement, eighty-five thousand dollars. Portage Lake, Mich.

Improving Patapsco River, Maryland: For continuing improvement of channel to Baltimore, three hundred and twenty-four thousand six hundred and forty-eight dollars. Patapsco River, Md.

Improving Potomac River: For completing improvement below the city of Washington, fifty-two thousand dollars. Potomac River.

Improving Pascagoula River and Horn Island Harbor, Mississippi: For completing improvement, two hundred and sixty-seven thousand six hundred dollars. Pascagoula River and Horn Island Harbor, Miss.

Racine, Wis. Improving harbor at Racine, Wisconsin: For completing improvement, sixty-seven thousand six hundred and fifty dollars.

St. Joseph, Mich. Improving harbor at Saint Joseph, Michigan: For continuing improvement, two hundred and fifty-three thousand nine hundred and fifty dollars.

Savannah River, Ga. Improving Savannah River, Georgia: For continuing improvement between Augusta and Savannah, sixty-four thousand dollars.

Sand Beach, Mich. Harbor of refuge at Sand Beach, Michigan: For continuing improvement and repairs, one hundred and fifty thousand dollars.

Sheboygan, Wis. Improving harbor at Sheboygan, Wisconsin: For completing improvement, fifty-two thousand dollars.

San Francisco, Cal. Improving harbor at San Francisco, California: For continuing improvement by the removal of Arch and Shag rocks, one hundred and seventy thousand dollars.

Sacramento, Cal. Improving Sacramento River, California: For continuing improvement from the city of Sacramento to the mouth of the river, sixty thousand dollars.

Tampa Bay, Fla. Improving Tampa Bay, Florida: For continuing improvement of channel from the Gulf of Mexico to Port Tampa, one hundred and thirty-five thousand dollars.

Toledo, Ohio. Improving harbor at Toledo, Ohio: For continuing improvement, one hundred and thirty-two thousand five hundred dollars.

Union River, Me. Improving Union River, Maine: For completing improvement, one hundred and fifteen thousand dollars.

Upper White River, Ark. Improving Upper White River, Arkansas: For continuing improvement by the construction of Lock and Dam Numbered Two, one hundred and fifty thousand dollars, to be done by contract or otherwise, as in the judgment of the Secretary of War may be most economical and advantageous to the Government.

Wilmington, Del. Improving harbor at Wilmington, Delaware: For completing improvement of Wilmington Harbor and Christiana River, two hundred thousand dollars.

Warrior and Tombigbee rivers, Ala. and Miss. Improving Warrior and Tombigbee rivers, Alabama and Mississippi: For continuing improvement of Warrior River by the construction of the three locks and dams next below Tuscaloosa, two hundred thousand dollars.

Mississippi River Commission.

MISSISSIPPI RIVER.

Head of Passes to Ohio River. Improving the Mississippi River: For continuing improvement of Mississippi River from Head of the Passes to the mouth of the Ohio River, including salaries and clerical, office, traveling, and miscellaneous expenses of the Mississippi River Commission, two million two hundred and fifty thousand dollars.

Mouth of Ohio to St. Paul. Improving the Mississippi River from the mouth of the Ohio River to Saint Paul, Minnesota: For continuing improvement from the mouth of the Ohio River to Saint Paul, Minnesota, two hundred and fifty thousand dollars.

MISSOURI RIVER.

Missouri River Commission.

Expenses, etc.

For improving the Missouri River from its mouth to Sioux City, Iowa: For continuing the improvement, including salaries and expenses of the Missouri River Commission, two hundred and fifty thousand dollars, to be expended under the direction of the Secretary of War in the improvement of the river at such localities as may be absolutely necessary in order to preserve existing improvements and to prevent threatened damage near Rulo, Nebraska, and other points; said work to be done according to plans and specifications to be made by the Missouri River Commission and approved by the Chief of Engineers: *Provided*, That the Secretary of War is authorized in his discretion to expend for improvement of the Missouri River at Sioux City, Iowa, so much as he may deem advisable, not to exceed twenty thousand dollars, of the appropriation of one hundred and seventy thousand dollars made by the act approved March third, eighteen and ninety-nine, for improving the Missouri River above Sioux City to and including Bismarck, and the sum of ten thousand dollars additional to the amount already apportioned from the said appropriation of one hundred and seventy thousand dollars for improving the said river at Elk Point, South Dakota, shall be expended at that place.

Rulo, Nebr.

Proviso.

Sioux City, Iowa.

Vol. 38, p. 1147.

Elk Point, S. Dak.

Bridge over Yellowstone River, Dawson County, Mont.

That the provisions of an Act entitled "An Act to authorize the construction of a bridge across the Yellowstone River, in the county of Dawson, State of Montana," approved February twenty-sixth, eighteen hundred and ninety-five, so far as they relate to and require a draw-span to be erected and maintained, are hereby so far modified as to permit the erection of an iron or steel bridge under said Act, without erecting and maintaining a draw-span in such bridge: *Provided, however*, That the spans of said bridge, when repaired and constructed, shall give not less than one hundred feet clear space between the piers, and that the two easterly spans shall give a clear headroom of twenty-five feet above low water, as defined in the Government surveys at the locality.

Draw, etc.

Vol. 28, p. 688.

Proviso.
Spans, etc.

COLUMBIA RIVER.

Columbia River, Oreg. and Wash.

For the repair of the jetty at the mouth of Columbia River, Oregon and Washington, including repairs to wharves, approaches, tramway, plant, quarters, and buildings, and contingent expenses, two hundred and fifty thousand dollars.

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MISCELLANEOUS OBJECTS, WAR DEPARTMENT.

Miscellaneous.

Maps.

For publication of maps for use of the War Department, inclusive of war maps, ten thousand dollars.

Survey of northern, etc., lakes.

SURVEY OF NORTHERN AND NORTHWESTERN LAKES: For printing and issuing charts for use of navigators and electrotyping plates for chart printing, three thousand dollars.

For surveys, including observations and investigations of lake levels, and all expenses connected with additions to, and correcting engraved plates, to be available until expended, seventy-five thousand dollars.

Transporting maps.

TRANSPORTATION OF REPORTS AND MAPS TO FOREIGN COUNTRIES: For the transportation of reports and maps to foreign countries through the Smithsonian Institution, one hundred dollars.

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California Débris Commission.

Vol. 27, p. 507.

Proviso.
Mileage of officers.

Vol. 30, p. 1109.

CALIFORNIA DÉBRIS COMMISSION: For defraying the expenses of the commission in carrying on the work authorized by the Act of Congress approved March first, eighteen hundred and ninety-three, fifteen thousand dollars: *Provided*, That so much of the Act of March third, eighteen hundred and ninety-nine, as provides that the members of the California Débris Commission shall receive only actual expenses in lieu of mileage while traveling on duty is hereby repealed, and hereafter the officers of the commission shall receive the mileage allowed by law.

New York Harbor.

HARBOR OF NEW YORK: For prevention of obstructive and injurious deposits within the harbor and adjacent waters of New York City;

Inspectors, etc.

For pay of inspectors and deputy inspectors, office force, and expenses of office, ten thousand two hundred and sixty dollars;

Vessels.

For pay of crews and maintenance of five steam tugs and three launches, fifty-eight thousand three hundred and forty dollars;

"Argus."

For new boiler and installing same, and generally overhauling steam tug Argus, seven thousand five hundred dollars;

In all, seventy-six thousand one hundred dollars.

* * * * *

Military road, Wyo.

Vol. 30, p. 50.

MILITARY ROAD, WYOMING: For the repair, construction, and completion of the military road from Fort Washakie to near Jacksons Lake, in Uinta County, Wyoming, authorized by provision in the sundry civil appropriation act approved June fourth, eighteen hundred and ninety-seven, ten thousand dollars.

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PUBLIC PRINTING AND BINDING.

* * * * *

Appropriation for new building.

Toward the construction of a fireproof building for the use of the Government Printing Office and for each and every purpose connected therewith, including the cost of all professional and other personal services that the Chief of Engineers of the Army may deem necessary, and for necessary books and periodicals, and for the rent of office rooms in a locality convenient to the work, to be expended under the direction and supervision of the said Chief of Engineers, seven hundred and seventy-five thousand dollars.

* * * * *

Approved, June 6, 1900.

CHAP. 792.—An Act Making appropriations for the support of the Military Academy for the fiscal year ending June thirtieth, nineteen hundred and one, and for other purposes.

June 6, 1900.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums be, and the same are hereby, appropriated, out of any money in the Treasury not otherwise appropriated, for the support of the Military Academy for the fiscal year ending June thirtieth, nineteen hundred and one.

Military Academy appropriations.

PERMANENT ESTABLISHMENT.

Permanent establishment.

* * * * *

For pay of one instructor of practical military engineering (major), in addition to pay as captain, mounted, five hundred dollars;

Extra [pay] to officers.

* * * * *

For pay of eight assistant professors (captains), in addition to pay as first lieutenants, not mounted, four thousand dollars;

For pay of five senior instructors of cavalry, artillery, and infantry tactics, ordnance and gunnery, and practical military engineering (captains), in addition to pay as first lieutenants, not mounted, two thousand five hundred dollars;

* * * * *

Approved, June 6, 1900.

RESOLUTIONS.

[No. 3.] Joint Resolution Granting permission for the erection of a monument in Washington, District of Columbia, for the ornamentation of the national capital and in honor of Samuel Hahnemann.

January 31, 1900.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That permission be, and the same is hereby, granted the Hahnemann monument committee of the American Institute of Homeopathy to erect a monument in honor of Samuel Hahnemann in such place in the city of Washington, District of Columbia, other than the Capitol or Library grounds, as shall be designated by the Chief of Engineers, United States Army, the chairman of the Joint Committee on the Library, and the chairman of the monument committee; and the sum of four thousand dollars, or so much thereof as may be necessary, is hereby appropriated, out of any money in the Treasury not otherwise appropriated, for the building of a foundation upon which to place said monument; said monument to be presented to the people

District of Columbia.

Erection of monument to Samuel Hahnemann authorized.

of the United States by the American Institute of Homeopathy, kindred associations, and citizens.

Approved, January 31, 1900.

February 17, 1900.

[No. 7.] Joint Resolution Increasing the limit of cost of the new building for the Government Printing Office, to meet the increased prices of building materials, and to permit of making the south end of the power house extension of the same height as the main building.

Government Printing Office.
Limit of cost of new building increased.
Vol. 30, p. 1120.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the limit of cost of the new building for the Government Printing Office, authorized by the sundry civil act approved March third, eighteen hundred and ninety-nine, be, and hereby is, increased by four hundred and twenty-nine thousand dollars, or so much thereof as may be necessary, to meet the increased prices of building materials, and to permit of making the south end of the power house extension, for a depth of about forty-five feet from G street, northwest, of the same height as the main building.

Approved, February 17, 1900.

March 19, 1900.

[No. 13.] Joint Resolution To provide for the removal of snow and ice in the city of Washington, in the District of Columbia.

District of Columbia.
Removal of snow, etc.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums are hereby appropriated out of any money in the Treasury not otherwise appropriated, namely:

* * * * *

For the removal of snow and ice, to be disbursed under the direction of the officer in charge of public buildings and grounds in and around Washington, District of Columbia, one thousand dollars.

Approved, March 19, 1900.

June 2, 1900.

[No. 30.] Joint Resolution Authorizing the printing of additional copies of the annual report upon the improvement and care of public buildings and grounds.

District of Columbia.
Public buildings and grounds.
Printing of additional number of copies of report on, authorized.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That there be printed each year hereafter, in addition to the number of copies now authorized by law, two hundred additional copies of the annual report upon the improvement and care of public buildings and grounds, and the care and maintenance of the Washington Monument, in the District of Columbia, for the use of the officer in charge of public buildings and grounds.

Approved, June 2, 1900.

PRIVATE ACTS.

CHAP. 471.—An Act For the relief of Edwin L. Field.

May 16, 1900.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of the Treasury be, and is hereby, authorized and directed to pay to Edwin L. Field, of Gray, Maine, three thousand seven hundred dollars, out of any money in the Treasury not otherwise appropriated, being the amount of a judgment against him recovered by James R. Atkins for personal injuries sustained by the parting of a guy to a derrick owned by the United States while being used by the War Department in the construction of the two-gun battery at Portland Head, in the town of Cape Elizabeth, Maine, provided said Field produces evidence satisfactory to said Secretary that he has paid said judgment.

Edwin L. Field. Payment to.

Approved, May 16, 1900.

CHAP. 924.—An Act Directing the issue of a duplicate of lost check drawn by James B. Quinn, major, Corps of Engineers, United States Army, in favor of Henry L. Breneman.

June 7, 1900.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That James B. Quinn, major, Corps of Engineers, United States Army, be, and he is hereby, authorized and instructed to issue to D. C. Rollins, a duplicate of an original check issued by said James B. Quinn on the thirteenth day of July, eighteen hundred and ninety-eight, numbered eighty-two thousand two hundred and seventy-seven, upon the assistant treasurer of the United States at New Orleans, Louisiana, in favor of Henry L. Breneman, for the sum of fifteen thousand three hundred and forty-eight dollars and ninety cents, which check is alleged to have been lost in transmission through the United States mails by said James B. Quinn: *Provided*, That said duplicate check shall be issued under such regulations in regard to its issue and payment as have been prescribed by the Secretary of the Treasury for the issue of duplicate checks under the provisions of section thirty-six hundred and forty-six of the Revised Statutes of the United States, including an adequate bond of indemnity.

Maj. James A. Quinn, U. S. A., may issue duplicate check to D. C. Rollins.

Proviso. Regulations, etc.

R. S., sec. 3646, p. 717

Indemnity bond.

Approved, June 7, 1900.

INDEX.

[The references in roman are to part (or volume) and those in arabic to page.]

A.

B.

D.

E.

F.

G.

L.

M.

N.

O.

P.

S.

T.

U.

V.

W.

Y.

O